AN INVESTIGATION INTO THE INCIDENCE OF FOOD PATHOGENIC BACTERIA IN SENIOR SECONDARY SCHOOL CANTEENS IN THE ASHANTI REGION OF GHANA AND THE EFFECT OF FOOD SAFETY INTERVENTIONS

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Dedicated to

My Father of blessed memory Mr. Sampson Acheamfour Ababio, My husband Mr. Samuel Asamoah and my sons Kobi and Junior

‘For those God foreknew, He also predestined to be conformed to the likeness of His Son that He might be the First born among many brothers. Those He predestined, He also called; those He called, He also justified, those He justified, He also glorified. Romans 8:29-30.

To God be the Glory

ABSTRACT

Food hygiene practices and standards and their implication on food safety among students in Senior High Schools in the Ashanti Region of Ghana and the effect of two food safety interventions were investigated due to increasing cases of food poisoning from schools reported in the media.

Forty five sampled schools in the Ashanti Region were audited and compared with 10 schools from Lincolnshire, UK, as a means of categorising the schools into hygiene standards. Whilst all schools audited in Lincolnshire were in excellent hygiene category (9.0 - 10.0), in the Ashanti Region, only 17.8% were in good category (7.0 - 8.9), 73.3% were in medium (5.0 - 6.9) and 8.9% were in poor hygiene category (2.0 - 4.9). Although 60% of the sampled schools in Ashanti Region served between 1000 – 3000 students daily, there was no evidence of Food Safety Management System in place and 52% of the 180 sampled students reported to have experienced foodborne infections 3-12 times per year within their 1 and 2 years in secondary school. Staff hygiene training was absent in schools which led to substandard hygiene practices with low food and personal hygiene test scores. Although there was supervision, 31% of the kitchen matrons reported they had no hygiene qualification in Ghana.

Early food preparation times with absence of hot holding equipment in the kitchens encouraged temperature abuse of Ready-to-Eat meals with Aerobic Colony Count (ACC), *Bacillus cereus,* total coliforms, *Staphylococcus aureus,* yeast and moulds counts exceeding the national acceptable limits for cooked meals. Lack of standardised hand washing and utensils cleaning procedure increased microbiological contaminants (ACC, coliforms, *S. aureus*, yeast *and* moulds) above existing advisory guidelines after washing.

Eleven schools from the Ashanti Region of Ghana after the hygiene categorisation were given GHP training as an intervention and the previous hygiene indicators reassessed. There were improvements in all hygiene indicators with significant differences in staff food hygiene knowledge (Z= -2.934, p=0.001), personal hygiene requirement (Z= -2.847, p=0.001) and food temperature (Z= -2.142, p=0.015) Post GHP. ACC, total coliforms and *Staphylococcus aureus* levels were significantly reduced ($p<0.05$) in jollof rice. Microbiological contaminants on food contact surfaces and staff hands reduced Post GHP with significant reduction in ACC and coliforms with the exception of serving pans.

Post HACCP results for all measured indicators were comparable to other international reports from schools with HACCP in place. Food temperature significantly improved [χ^2 (2) =8.400, p=0.008]. Jollof rice microbiological contaminants reduced with up to 100% satisfactory rate for ACC and yeast and moulds, 80% for *Staphylococcus aureus* and 60% for *Bacillus cereus.* Coliforms significantly reduced [χ^2 (2) =9.580, p=0.002] but had only 40% satisfactory rate. Post HACCP ACC on staff hands and food contact surfaces were significantly reduced ($p<0.05$) and also yeast and mould for the latter [χ^2 (2) =7.600, p=0.024]. Reduction of total coliforms was not significantly different for both staff hands and utensils probably due to absence of disinfection. Food service/dishing time reduced to the agreed time (30-60 minutes) to student's meal time.

Post hoc analysis with Wilcoxon's signed-rank test was conducted with Bonferroni's correction. There were significant reductions in Post GHP - Pre GHP; food temperature (Z=-2.625, p=0.003), *S. aureus* in jollof rice (Z=-2.803, p=0.001), ACC (Z=-2.578, p=0.003), yeast and mould (Z=-2.490, p=0.005) on food contact surfaces.

There was enough evidence to prove that GHP significantly improved hygiene and food safety. The study recommends the introduction of GHP and applied HACCP principles in schools.

Key Words: School meals, staff hygiene, microbiological safety, Food safety interventions

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS

1. ACC Aerobic Colony Count
2. BRC British Retail Consortium
3. CFU Colony forming units
4. HPA Health Protection agency
5. HACCP Hazard analysis and critical control point
6. GHP Good Hygiene Practices
7. FAO Food and Agriculture Organisation
8. FCS Food contact surfaces
9. FHKs Food hygiene knowledge scores
10. FSSC Food Safety certification systems
11. MoFA Ministry of Food and Agriculture
12. MoH Ministry of Health
13. MoE Ministry of Education
14. PHRs Personal hygiene requirement scores
15. IFS International featured standards
16. RTE Ready to eat food
17. SQF Safe quality food
18. SHS Senior High Schools
19. SMEs Small and Medium Scale enterprises
20. SPM Sanitary and phytosanitary measures
21. TBT Technical barriers to trade
22. UNESCO United Nations Educational, Scientific and Cultural Organisation
23. WHO World health organisation
24. WTO World trade organisation

TERMS

1. Food holding time- Time cooked food was sampled until official student's meal time was due.
2. Prerequisite measures - These are procedures and controls in place to ensure good practices in food processing

CHAPTER 1

1.0 INTRODUCTION

The provision of quality food in schools is of great concern to governments and other stake holders as it improves the health, growth and development of beneficiaries and also encourages continued education in developing countries (Van Fleet and Van Fleet, 2010, Espejo *et al* 2007, Santana *et al*, 2009, Oranusi, *et al* 2007, Tonder, 2007, Afoakwa, 2008 and WHO, 2002). This beneficence is challenged as there are increasing reported cases of foodborne disease (FBD) outbreaks from schools worldwide (BBC, 2011, Mushaireen *et al*, 2010, Santana *et al*, 2009, WHO, 2002, Daniels, 2000, Richards *et al*, 1993). In Japan within seven months in the year 1996, 11,826 cases with 12 deaths from *E. coli* 0157: H7 infection were reported in schools, whilst in Brazil 11.6% of documented FBD in 2005 were from school catering services (Santana *et al* 2009). In the year 2010, 544 adolescents had Salmonella food poisoning in France whilst 11,200 students in Germany from several hundreds of schools were affected with norovirus in the year 2012 (Marzona and Balzeratti, 2013). The incidence of foodborne related diseases is rising in Ghana, in the year 2002, 2.3 million cases of foodborne illness were reported in Ghana's health institutions, the World Health Organisation (WHO) reported, 1.8 million people died from diarrhoeal diseases of which a great proportion was attributed to contaminated food and drinking water in 2005. The Food and Drugs Authority of Ghana reported of 90,692 deaths related to food and personal hygiene illness in 2006 and in 2007 the WHO reported that 1 in every 40 Ghanaians suffer serious foodborne illness annually (Ministry of Food and Agriculture and World Bank, 2007). Reporting and publicity of foodborne diseases is low (Tomlins *et al*, 2002) in Ghana, although commercial food services including street 'vendored' food and agricultural produce have been associated with high contamination risk (Mensah, 2002, Amoah, 2006, Feglo and Sakyi, 2012). There have been reported foodborne disease outbreaks from schools in the media including Daily Guide, (2007), Joy News, (2008, 2010), Citi FM, (2013) and the Ministry of Health's annual report (MoH, 2007) but no survey on hygiene practices and microbiological quality of meals available in school canteens in Ghana has been conducted thus warranting this study.

Food hygiene practices in schools have been reported to require interventions to ensure safe meals for students internationally (Bankolé *et al*, 2012, Youn and Sneed, 2003). Rodrguez-Caturla *et al* (2012) studied the hygiene practices and microbiological status of food in Spanish school canteens and reported on the need to improve cleaning procedures and recommended the need for an intervention. In Indonesia, Adolf and Azis (2012) researched on the microbiological status of food served in schools with different socio economic backgrounds and concluded that sanitation practices and environment of workers rather affected food safety and not socio economic background, these researchers did not have any intervention for schools. On the other hand Santana *et al* (2009) in Brazil studied the microbiological quality and safety of meals served in school canteens and implemented Good Manufacturing Practices (GMP) to evaluate effect of the intervention. He reported of higher scores from food safety check list and reduced numbers of total microbial load in meals after the intervention. Santana *et al* (2009) alone from the above presented an intervention in their study in schools but did not show whether the changes, Post-intervention, were significantly different from Pre-intervention practices. Other researchers report on lack of evidence on changes in hygiene practices after training (Soares *et al* 2012, Eghan *et al* 2007, Kwon, 2003 and Ehire *et al* 1996). This research sought to establish the significant effect of GHP and HACCP interventions on food hygiene practices and food safety as a whole statistically.

Food researchers in Ghana have focused much attention on food safety practices and food microbiological quality of the commercial sector (street foods, hotels and processing industries) and primary producers (Saba and Gonzalez-Zon, 2012) of the food chain. Tortoe *et al*, (2013), Ababio (2011), Feglo and Sekyi (2012), Johnson *et al*,(2008), Addo, (2007), and Tomlins *et al*, (2002) have reported on the need to improve on Good Hygiene Practices to ensure food safety in commercial catering. Institutional set ups including schools and hospitals have not had equal attention. Also microbiological food analysis has been limited to *Enterobacteriaceae* and selected pathogens including *Salmonella spp*, *Campylobacter jejune and Bacillus cereus* (Saba and Gonzalez-Zon, 2012).

Pupils at the basic level and students in tertiary institutions have variety of meal sources but those in the Senior High Schools (SHSs) and using boarding facilities are mostly restricted to subsidized meals prepared and served in schools (Afoakwa, 2005). Bankole *et al* (2012) reported on high levels of pathogenic and spoilage bacteria including feacal sources of contaminants from caterers hands, nose and mouths in schools posing a potential risk due to their practices in Benin. Hwang *et al* (2001) reported that the demographics of food service managers positively relate to their food safety practices. Henriod and Sneed (2004) also added that food safety managers with food certificates, in other words trained, have higher food safety practice score (p=0.019). The effect of food hygiene awareness and training on handlers according to other authors; Egan *et al*, (2007), Ehiri *et al*, (1996) and Soares *et al*, (2012) are ephemeral as high proportion of food poisoning occur in commercial settings as a result of poor food handling practices. This work investigates existing hygiene practices and standards in school canteens in the Ashanti Region of Ghana and the effect of food safety interventions.

CHAPTER 2

2.0 LITERATURE REVIEW

The chapter addresses the general and specific issues on food safety, the international and nation specific responsibilities of Governments and other stakeholders towards consumers.

The overall legal requirements of food safety and identified limitations with special reference to institutional catering services was addressed. HACCP a food safety management tool recommended for use along the food chain was also addressed.

2.1 Food safety concerns worldwide and individual country's responsibilities.

Foodborne illness is among the most widespread public health problem, creating social and economic burden as well as human suffering, making it a concern that all countries need to address. Foodborne diseases range from fever, gastroenteritis, chronic complications that can have lifetime health consequences (paralysis, kidney failure, irritable bowel syndrome, Guillain-Barre syndrome and arthritis) to premature death.

These present economic burdens on individuals, institutions, nations and the world as a whole. Governments world over have developed food legislation to protect their citizens from these food diseases which sometimes could be fatal (Youn and Sneed, 2003, MOFA/WorldBank, 2007), by ensuring that food produced are hygienically made and that Food Safety Management Systems are consciously implemented and maintained to safe guard consumers against poor hygiene practices. Food production, handling, storage, preparation, processing and transporting methods have improved giving way to more nutritious, consumer acceptable varieties of food, ready to eat meals (RTE) at economic prices and many more. The traditional methods of food handling giving way to much more unconventional methods including chilling, freezing, cook-chill, cook freeze, pasteurization and shelf life extension has resulted in questionable health consequences. This has caught the attention of government's world over as food produced in one country due to world globalization has a direct effect on consumers in an importing country. A local foodborne disease outbreak is a potential threat to the entire globe. To police safety across borders there have been developments on agreed terms of trade where member countries can ensure that food crossing their boarders are up to the decided acceptable standard or appropriate level of safety not withstanding there is a quest for scientific evidence as proof by member countries as a means to restrict unscientific barriers to trade by protecting their internal market from external competition within the Sanitary and Phytosanitary Measures and Technical Barriers to Trade (TBT) agreement (WTO, 2001).

Increasing consumer concerns on food safety has caused an increase in the numbers of Food Safety Management systems. Increased numbers have also resulted mostly as different standards have been developed my businesses in different countries to be on a competitive edge (Sansawat and Muliyil 2011). Increasing standards brought about daunting documentation with repetitions over similar requirements as different customers (retailers) in developed countries demanded for different standards from manufacturers. This brought the birth of Global Food Safety initiative that umbrellas most of the internationally recognized standards (Sansawat and Muliyil, 2011) including ISO 22000, Global Food Standard (BRC), Food Safety System Certification (FSSC, 22000), International Features Standard (IFS), Safe Quality Food (SQF) and many other primary production schemes. These are sometimes costly and difficult to implement mostly for developing countries where the food industry is still full of Small and Medium Size Enterprises (SMEs) with limited financial, human resource with expertise, infrastructure and available technology (Yapp and Fairman, 2006).

The World Health Organisation (WHO) and Food and Agriculture Organisation's (FAO) Codex Alimentarius Commission an intergovernmental body developed to ensure fair trade practices and consumer protection has developed the standards that are internationally recognized including the Codex Food Hygiene, a basic text promoting the understanding of how rules and regulations on food hygiene are developed and applied (WHO/FAO, 2009).

These will be termed as the Good Hygiene Practices (GHP) designed for food industries from primary production through to consumption. They are Prerequisites Measures (PRM) upon which other Food Safety Management Systems can be built however could be useful to ensure safe food if effectively implemented and maintained.

Table 1. Foodborne diseases and economic impact (monetary) on 3 developed and 3 developing countries by different authors

Country	Foodborne illness	Reported cases /hospitalisation annually	Death related to foodborne illness annually	Cost to country annually	Author
US	80 million	DNA	9000	$ 5.0 billion	Altekruse *et al*, (1997)
	76 million	325,000	5000	DNA	Mead *et al* (2001)
	47.8 million	127,839	3037	$ 152.0 billion	CDC (2011)
UK	17 million	1,000,000	DNA	**$844.8 million	FSA (2011)
	1 million	20,000	500	***$2.4 billion	FSA(2010)
Australia	5.4 million	1,200,00	DNA	$1,249 million	ADHA(2006)
Ghana	DNA	420,000	65,000	$ 69.0 million	MOFA/World Bank (2007)
Nigeria	DNA	*90,000	200,000	$ 3.0 billion	WHO (2009) as in Ebenso *et al* (2012)
Benin	DNA	309,944	331	DNA	Ministere de la Sante Publique (2006) in Bankole *et al* 2012

*** Author recognizes this as an underestimation in Nigeria foodborne illnesses**
**** 11 million days costing = minimum wage in UK in 2011 [(6 GBP) x 8 hours] 11,000000.00 multiplied by pound dollar rate (1.6)**
*****1.5 billion GBP converted to Dollars using 2010 rate**
DNA = Data not available

The body also recommends the use of Hazard Analysis and Critical Control Point, an internationally applaud food safety tool that works on analysing specific hazards related to specific operations and developing ways of preventing, eliminating and or controlling these identified hazards to ensure safe food (Wallace, 2006). This will be extensively handled in subsequent sections. Food borne illness affects all generations but those mostly at risk are the elderly, infants, pregnant women and the immunocompromised patients (HIV/AIDS, cancer patients, cirrhosis that impair the immune system).

From Table 1, food safety obviously has become a global issue irrespective of one's location costing governments and individuals huge sums of money. In Ghana, Odame- Darkwa (2008) of the Food and Drugs Authority added that foodborne diseases were generally reported to have killed 90,692 people with 297,104 reported cases at Outpatient departments in hospitals costing the government GHC 594,208.00 and approximately 594,279 productive days in 2006. Effective measures are therefore recommended by each government to prevent adverse human health and related economic consequences of foodborne illness and injury. Similar measures of protection or even higher measures above the acceptable international standards are being taken by countries to ensure the safety of their consumers by improving local hygiene and safety practices and taking stringent measures with surveillance and monitoring of imports into their countries.

2.1.1. *Global standards*

The World Trade Organisation's Sanitary and Phytosanitary Measures agreement built on the General Agreement on Tariffs and Trade gives Governments the opportunity to decide on the appropriate level of safety for its country and are encouraged to operate with standards developed by relevant international bodies to ensure smooth trade and also safety for the populace without unjustifiable discrimination between member countries. Members may use standards that may demand higher levels of health protection and quality which sometimes brings about trade disputes and refusal of smooth trade especially between developed and developing countries. The Food and Agricultural Organisation /World Health Organisation's Codex Alimentarius Commission standards based on input of leading scientists in food safety is considered the overall general standard to operate within the food industry (CAC, 1993). There are other food safety and quality assurance standards including the International Organisation for Standardisation (ISO) standards for food safety management, ISO 9001 and 22000, other third party standards including, Global Food Standards (British Retail

Consortium), International Food Standards (IFS), Safe Quality Food (SQF) level 2000 among others (Mensah, 2011).

Good Manufacturing practices, Good Hygiene Practices and Good Agricultural practices are all prerequisites measures (PRM) that can be taken by food industries to control food producing and processing activities.

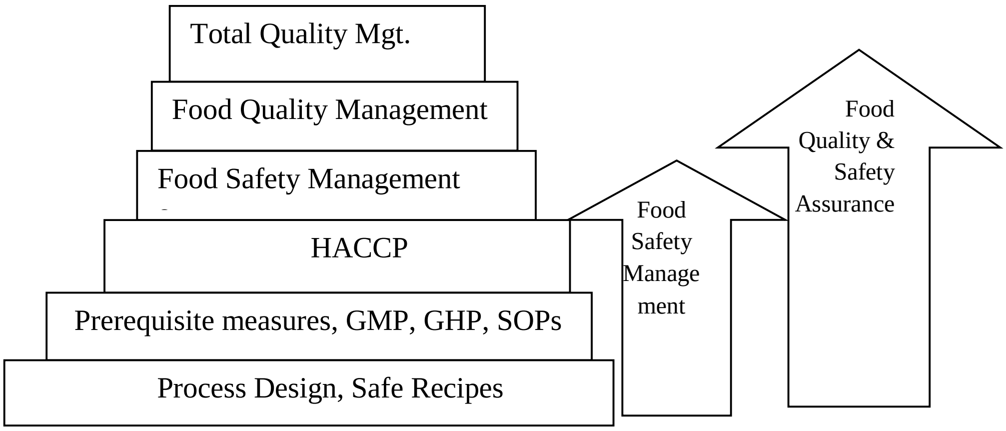


Fig.1 Steps in the development of Food safety and quality management systems

From Figure 1, HACCP is built on available PRM and it happens to be a spring board for all other food safety management systems (Sikora and Strada, 2003, Youn and Sneed, 2003) Members are encouraged to respect other members and their standards as long as there is a level of equivalence in safety levels set in their respective countries.

Food safety is a legal obligation on the part of all food handlers (Sikora and Strada, 2003) and a non-negotiable subject as lives of consumers depend on it. Safety looks at ensuring that there is absence or acceptable levels of food hazards in food for sale. Food quality management on the other hand includes safety and other attributes like sensory, nutritional, weight and packaging which are mostly voluntary measures. Thus while the sensory characteristics, type of packaging and weight and sometime nutrition could be decided based on customer specification, food safety assurance is a legal requirement subject with statutory consequences including fines and imprisonment when breached. It is thus an offence to offer food for sale that is unwholesome to eat or contains in or on it substance that is injurious to health according to the Food and Drugs Act, PNDCL 305B in Ghana, the 2012 Public Health Act 851 (FDA, 2012) of Ghana and 1990 Food Safety Act of the United Kingdom.

2.1.2. *Minimum requirements*

Unlike bigger food industries which have the expertise, required equipment and facilities, staff numbers and financial capabilities and hence can go for third party systems as marketing strategy and sometimes based on customer interest and demand (Yapp and Fairman, 2006) medium and small scale industries (SMEs) mostly lack a combination of these qualities and are not in position to go for voluntary systems which bring additional financial burdens. However there are obligatory systems that are put in place to ensure safety and these are to be enforced (Fig. 2).

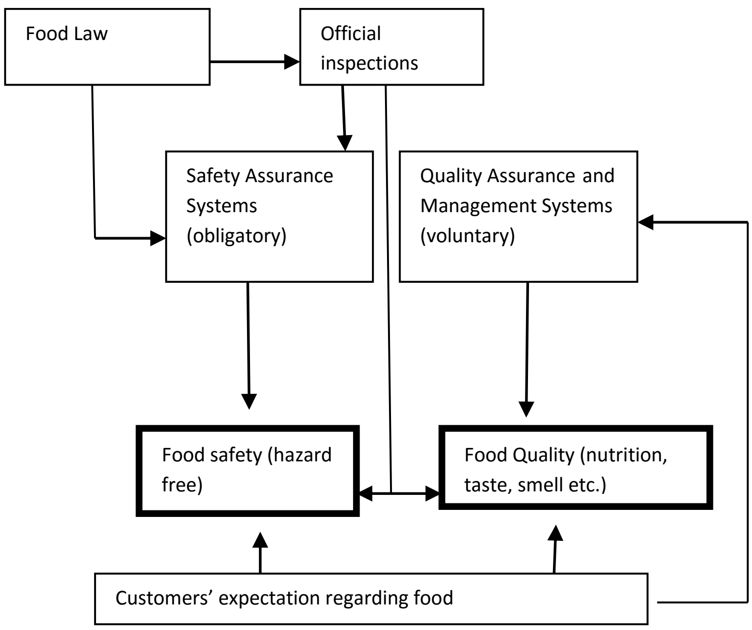


Fig 2. Integrated diagram of obligatory and voluntary food operation and management systems (Sikora and Strada, 2003)

Good hygiene practices, Good Manufacturing practices and Good Agricultural practices are all primary or prerequisite systems used as long as one is of the position of growing, preparing, storing, and transporting, processing and manufacturing food for sale.

HACCP is equally recommended by the World Health Organisation and Food and Agriculture organizations Codex Alimentarius to be used in the food industry. HACCP is industry specific and can be applied based on system in place thus the more complex your system the extra demanding HACCP implementation and maintenance would be. Thus Governments are mostly concerned with food industries operating with safety in mind and also maintaining good health among consumers. From Figure 2, provisions are put in place to ensure consistency in the form of surveillance. It is the responsibility of National Governments and Food Safety Agencies to ensure compliance by industry to national food quality and safety requirements. These systems whilst in place and operated accordingly suffices the needed legal requirements. Other quality management systems as mentioned go beyond safety and legislation to ensure customer interest is satisfied.

2.1.3. *Basic food hygiene*

The key principles of food safety captured in five keys for safer food developed by the WHO are;

i. keep clean

ii. separate raw and cooked food

iii. cook food thoroughly

iv. keep food at safe temperature and

v. use safe water and raw material (Blackburn and MacClure, 2009)

These requirements are considered the principles on which all prerequisites (GMP, GHP, and PAS 220 of ISO 22000:2005) are built. They ensure that food prepared for sale is safe. The Codex Food Hygiene Basic test (WHO/FAO, 2009) outlines the following requirements in 7 out of its 10 sections for the processing, manufacturing and food service operators and retailers in the food industry and consumers alike;

Section 4. Establishment design and facilities

Section 5. Control of operations

Section 6. Establishment of maintenance and sanitation

Section 7. Establishment of personal hygiene

Section 8. Transportation

Section 9. Product information and consumer awareness and

Section 10. Training

Under each of these sections there are subsections detailing what the industry is supposed to do to ensure compliance. These are considered the recommended international Code of Practice, General Principles of Food Hygiene, CAC/RCP 1-1969. They are general activities that are in place to control food safety and are applicable across all areas of food operation.

Kagan and Sholtz (1984) classified businesses management attitude to legislation into three different types;

i.”Amoral calculators”, those who are entirely by profit–seeking. Noncompliance stems from an economic calculation.

ii. “Political citizens”, these are ordinarily inclined to comply with the law but non-compliance stems from a principled disagreement with regulations regarded as arbitrary or unreasonable.

iii. “Organisationally incompetent”, whereby non-compliance is attributed to failures of management, knowledge and systems.

The question is which group currently dominates the Ghanaian food industry? Are members being non-compliant, and if they are could lack of; enforcement, infrastructure, knowledge of principles and regulations, finance be the problem? Or are businesses playing politics with the system?

2.2 HACCP and the food industry

Hazard Analysis and Critical Control Point is simply a food safety tool used in the industry to look at what can go wrong at each step in the process with subsequent building in of controls to prevent the problem from occurring. It is a system of risk management developed to control food safety (Gilling, *et al* 2001). It was developed as part of the American manned space programme in the late 1950's/early 1960's when Pillsbury company in collaboration with National Aeronautics and Space Administration (NASA) and United States Army laboratories worked on developing suitable foods for the astronauts in space (Wallace, 2006). This team adopted the system Failure Mode and Effect Analysis approach in engineering as the basis of HACCP system to replace the then existing food control measure that depended on end product testing which was destructive and could not be relied on, as for 100% surety, all food had to be tested leaving none for consumption. Its use has been recommended by the US National Academy of Sciences, the International Commission of Microbiological Specifications for Foods and Codex Alimentarius Commission for use in both the food industry and regulatory authorities. (Gilling *et al*, 2001).

HACCP has a total of twelve steps to consider in its implementation. The last seven are considered as the Principles. The twelve stages are;

1. Assemble HACCP team
2. Describe product/processes
3. Identify intended use
4. Construct process flow diagram(s)
5. On site confirmation of flow diagram
6. List all potential hazards associated with each step, conduct Hazard analysis and consider any measures to control identified hazards
7. Determine Critical Control Points (CCPs)
8. Establish critical limits for each CCP
9. Establish a monitoring system for each CCP
10. Establish corrective actions for deviations

11. Establish verification procedures

12. Establish documentation and record keeping (CAC, 2009, Wallace, 2006)

HACCP introduction in the food industry has been a gradual process. Initially countries made it voluntary and mostly larger manufacturers used it. In the 1990's, the World Health Organistion's Codex Alimentarius Committee recommended the use of HACCP principles as part of its Basic Hygiene Requirements internationally. Most countries have made HACCP a legal requirement including Europe, United Kingdom, Australia, Canada, New Zealand and now the United States (FDA, 2011). HACCP has now become an integral part of all internationally accepted food safety standards and is in use by food manufactures and processors who trade across borders and in countries where both consumers and legislation call for responsibility of food safety to be on the industry. Small businesses on the other hand have difficulties adapting HACCP with some related issues being lack of training and skilled personnel, finance, excessive documentation, lack of time among others (Taylor *et al*, 2001). This author on the other hand realizes that most of the reported time consumed in documentation originate from inappropriate development of the system. Another issue is that most small enterprises do not want to commit or pay for changes that have been initiated externally. Small and Medium scale enterprises are the largest contributors of service in the food chain both in developed and developing countries (WHO, 1999, Gilling *et al*, 2001) and sustaining their business through Government interventions in safety will strengthen the food industry.

The Food Standard Agency of the United Kingdom, has reported on dramatic effect on the reduction of foodborne diseases with the number of cases of people getting sick falling by 1.5 million with 10,000 fewer hospitalization saving the economy £750 million due to interventions like regulation (Hygiene rules inclusive), training (toolkit of guidance and resources to assist small catering businesses to comply with new legislation on HACCP based

Food Safety Management inclusive) and public information campaigns (FSA, 2011). The United States Food Safety Mordenisation Act has been developed as cost to the economy through foodborne illness remained high at forty eight (48) million cases, 138,000 hospitalisation and 3000 deaths annually. The Center for Disease Control and Prevention (2011) reported on a 20% decrease in foodborne disease but the estimates remains high as 1 in every 6 persons get foodborne related disease annually. The Act requires mandatory preventive control from food facilities. Food facilities are required to implement written preventive control plans. These involve evaluating the hazards in food, stated preventive steps taken or controls to significantly reduce or prevent the identified hazard, documented monitoring plans to ensure system efficiency, record keeping and stipulated corrective actions in case of deviation (Food and Drugs Administration, 2011). This is in line with HACCP principles. In training and implementing HACCP the kind and size of the food set up should be considered.

2.2.1 *Benefits to implementing HACCP*

These have been categorized under three major beneficiaries by the WHO (1999)

Consumer benefits include

-Reduced risk of foodborne disease

-Increased awareness of basic hygiene

-Increased confidence in the food supply and

-Improved quality of life (Health and socio-economic)

Benefits to industry

- Increased consumer and government confidence
- Reduced legal and insurance costs
- Increased market access
- Reduction in production costs
- Improved product consistency

- Improved staff-management commitment to food safety and
- Decreased business risk

Benefits to governments

- Improved public health
- More efficient and targeted food control
- Reduced public health costs
- Trade facilitation and
- Increased confidence of the community in the food supply

2.2.2 *Barriers to adherences*

There have been several studies on the reasons why even in countries where HACCP has been legalized the industry and mostly SMEs have difficulties enrolling. Taylor *et al* (2001) reported awareness, attitude and behavioural setbacks in the industry as major contributors. The WHO (1999) reported on the following as barriers regardless of the background or setting of the enterprise.

- Lack of government commitment
- Lack of customer and business demand
- Absence of legal requirements
- Financial constraints
- Human resource constraints
- Lack of expertise and or technical support
- Inadequate infrastructure and facilities and
- Inadequate communications

Herath and Hension (2010) added the lack of market competition, other responsibilities and reluctance of firms to realize the associated profit as HACCP implementation barriers.

2.3 Food safety in Ghana

Ghana is a West African country with a land area of 238,527 Km^2 and a population of 24,658,823 (Ghana Statistical Service, 2012). The country is divided into 10 main regions with Accra as the capital city. Kumasi the second most urbanized city is in the Ashanti Region which from the 2010 population census is the most populated region in the Country. Organisations responsible for food safety and control in the country include the Ghana Food and Drugs Authority, Ghana Standards Authority and the Environmental Health Departments or units of the Metropolitan and District Assemblies. Others include the Ministry of Food and Agriculture and the Ministry of Health. The Ghana Education Service also has a School Health and Education Programme Unit (SHEP) that is responsible for school sanitation and hygiene education for all educational institutions below tertiary level (Owusu, 2008, GES, 2012). Food preparation traditionally in this country is a woman's place and this has reflected in most demographic reports of workers in this field. Level of education (formal) which is considered to have direct positive effect on Good Hygiene Practices is low among food handlers in Ghana (Ababio *et al*, 2012, Ackah *et al*, 2011, Tomlins *et al,* 2002) The World Health Organisation (2009) reported of high levels of diarrhoeal cases of which a higher percentage were due to food and water borne infections. According to the Ministry of Food and Agriculture (MoFA) and World Bank (2007) report, 1 in every 40 Ghanaians suffer serious foodborne illness per year, 420,000 cases are reported with an annual death rate of 65,000 which costs the Ghana government US $ 69,000,000.00 annually. This report could be an under estimate as in the United Kingdom for instance where there is high reportage, every case reported is still said to have over 3 to 100 unreported cases (FSA, 2011) also in the calculation of cost in the developing countries only cost borne by individuals through hospitalization and medication is considered whilst others consider the cost to employers, institutional bodies like laboratories, surveillance, disability cost and cost from other family members who take care of the sick member, premature mortality among others (Abelson *et al*, 2006) . Food handlers in general and mostly food vendors and catering services have been implicated in poor hygiene practices (Feglo and Sakyi, 2012, Addo, 2007, Afoakwa, 2005, Tomlins *et al*, 2002). Research covering the hospitality industry has been around hotels and street food vendors mostly in the capital city, Accra (Ackah *et al*, 2011, Donkor *et al* 2009, Addo *et al*, 2007). High levels of bacterial contamination in street vendored food beyond the acceptable reference figures of Ghana Standard Authority ($< 5.0 \log_{10} CFUg^{-1}$) has been reported by Feglo and Sakyi (2012). Yeboah *et al*, (2010) reported of *E. coli* in 'waakye' (rice and beans mix) with average levels of ACC being 1.39×10^5 $CFUg^{-1}$. Although pathogens like *Salmonella* were absent in food sampled including fried rice, waakye, plain rice and tomato source, *Staphylococcus aureus* was found in waakye sampled due to vendors handling practices. Nyarko *et al*, (2011) reported of high ACC ($>10^6$ $CFUg^{-1}$) and yeast and mould levels ($>10^4 CFUg^{-1}$) in grilled fish sold on the market in Tema Accra. Amissah and Owusu (2012) who investigated food safety on a Polytechnic campus at Koforidua in the Eastern region reported of unacceptable levels of *E. coli* and *Staphylococcus aureus* in fufu samples although *Salmonellae* was not detected. Bempah *et al* (2011) reported of high levels of pesticide residues in locally produced fruit-based drinks in Ghana and Amoah *et al* (2006) reported that 80% of vegetables sampled from 3 cities across the country were contaminated with residue levels exceeding the Minimum Residual Limits (MRL) of the EU for positive samples. Hotels in the Capital region have reported level of improvement in hygiene practices but with the need for improvement in cleaning of food surfaces which have high levels of Coliforms present and in other locally prepared juices (Addo *et al*, 2007). There are knowledge gaps about the prevalence rates of food allergy in Ghana, however Obeng *et al* (2011) and Boye, (2012) reported of peanuts and pineapple as the main source of food allergy in children between the years of 5 and 16. Eleven percent (11%) of 1,407 school children sampled in Ghana reported to have adverse reactions to selected foods with 5% showing a positive response to skin prick test (SPT) (Obeng *et al*, 2011). Ababio and Adi (2012) and Ababio *et al* (2012) reported on low level of education among food handlers in the Ashanti Region of Ghana which is the highest populated region in the country with limited numbers of Food Safety Management Systems across the country mostly among locally owned businesses which goes to prove the lack of management commitment to legislation and customer requirement. Whilst research into commercial catering in the country is high, work in the welfare catering sectors including schools, hospitals and prisons for instance provide limited information. There are however few reports from news agencies when foodborne illness and other cases related to schools arise (Daily guide, 2007, Joy news, 2008, 2010 a&b). There is a growing concern as food handlers in the country have overlooked documentation and quality assurance part of food production. There is no special qualification for persons who prepare food for sale and this affects the acceptable practices in food preparation. Whilst it is mandatory as a public health policy for food handlers to be screened before preparing food for sale (Feglo *et al*, 2004), a research conducted by Ackah *et al* (2011) showed that only 40% out of sampled food handlers for their study had health certificates and there was absence of periodic screening in the capital city of the country. Ababio and Adi (2012) reported of higher level of screening but lack of renewal in Kumasi of the Ashanti Region. According to Mensah (2011) the government of Ghana through the Ghana Standard Authority has started a capacity building program to equip enterprises with the knowledge and competence for food safety through training programs with a United Nations Industrial Development Organisation (UNIDO) sponsorship and SGS International (Societe Generale de Surveillance) as the contracted body for training as currently there is no accreditation institution in the country. Training of personnel is a recommendation under all prerequisites, the Codex Alimentarius Commission's (WHO/FAO, 2009) Good Hygiene Practices Basic texts recommends all governments to ensure that food handlers receive the necessary training to equip them for their work. Training is one of the requirements that is seriously neglected by the food industry in the country as reported by Ababio *et al* (2012). Planned maintenance is reported to be lacking in the industry, proper cleaning and disinfection, waste management and pest control, supplier control and raw material sourcing are existing but mostly undocumented and hence not standardized as reported by the researcher. HACCP, a food safety tool upon which all other food safety assurance systems are built is rarely known and or used among food handlers and Johnson *et al* (2008) refer to its use as contingent in addressing food safety constraints in the country. Feglo *et al* (2004) in their work on *Salmonella* carrier status of food vendors in Kumasi Ghana, supported the idea that in developing countries where money and time required to improve existing environmental standards might demand longer waiting periods, the most efficient way to improve on the hygiene activities of food handlers will be through education and regular surveillance as food handlers in the region were concluded to be of significant risk in the spread of enteric fever. One of the characteristics of a growing economy is longer food supply chains to satisfy the demands of emerging affluent consumers locally and to access external market with locally produced raw materials and processed foods which brings in foreign exchange aiding rural development. This calls for quality and safe produce which is achievable only through the strengthening of laws, institutions and infrastructure (MOFA/World Bank, 2007). According to their report, the legislative and institutional frame work in the country is outdated and characterized by overlaps and ambiguity in institutional responsibilities bringing about inefficiencies and increased overhead costs and loss of national and international competiveness in the private sector. Sectors that currently have good international standards include the cocoa, fisheries and vegetable subsectors thus primary producers in the food chain who are in exporting business (MOFA/World Bank, 2007). The internationally owned enterprises are also mostly operating according to documented standards available internationally (Ababio *et al*, 2012).

2.3.1 *Government interventions in UK an example for Ghana*

The food industry is only as strong as its weakest link in the food chain (Taylor, 2001). The food industry in every nation whether developed or not stands to lose if all stages in the food chain are not motivated and strengthened to use food safety approaches. On the other hand ignorance on the part of both consumers and producers about the gross effect of foodborne diseases caused by poor hygiene practices and the believe that practices in use have always been safe stands to kill any hope of improving on food safety and quality assurance in Ghana. The benefits of reducing hazards in food include reduced morbidity, mortality and demands on healthcare services, a reduction in absences from education or loss of productivity at work and increased consumer confidence in food safety (FSA, 2011) however a report from Mensah (2011) indicated that Ghana is not ready for HACCP. This is attributed to lack of food safety capacity, regulatory backing and lack of streamlined responsibilities on policy enforcement agencies, lack of consumer awareness and education all having militating effects against good practices in the food sector. Food handlers across the food chain up to the consumer need to be sensitized on the role of compliance with food safety requirements.

Education is the key but without the existing resources and infrastructure, implementation becomes a problem. HACCP is built on Good Hygiene and Manufacturing practices which are mostly called Prerequisite measures for HACCP. These need to be available and enforced as the basic requirements for food industries. Upon this HACCP which is a more flexible, industry specific food safety tool could be built hence raising the standard of food industries in Ghana to an international level of operation and practice (FAO/WHO, 2009). This notwithstanding could be difficult for SMEs who might not have the resources to establish acceptable systems. Government and local authorities interventions in the form of free or subsidized training, developed food safety standards by appropriate agencies and training manuals and videos on good practices for individual industries, could go a long way to solve some of these hurdles (FSA, 2007). The Food Standard Agency of the United Kingdom (England and Wales) in the year 2005, a year before the Government made the use of HACCP in the food chain with the exception of primary production (EC Law) a mandate, developed a simplified food safety management pack entitled Safe Food Better Business for small catering and retail businesses upon request. Other sister countries developed similar packs in Europe for the food industry operating as micro, small to medium industries upon request. This was a common aim though realizing the differences that existed in business that there would be some form of best practice approach across board. This effort has extremely improved the industry with reported over 93% of 1,143 SME's surveyed across Europe enrolling with positive feedback on benefits including, confidence, preparedness for EHO's visits, effective training, reduced waste and hence cost and overall profit increase. Another effort by the UK government is the Accelerated HACCP Project for the meat industry in which a £ 9 million government project aimed at implementing HACCP in 7000 independent retail butchers (Gilling, 2001) after an *E. coli* outbreak in Scotland killed 21 consumers. Thus realizing the fact that industries are willing to commit to safer practices if help is available.

Schools, small catering and retail businesses in the England and Wales through the Food Standard Agency have received simplified versions of HACCP packages entitled, Safer Food Better Business, similar packs has been made available in Scotland called Cooksafe and Northern Ireland has developed one entitled Safe Catering which help kitchen managers to manage food safety effectively (FSA, 2007). The Food Standard Agency in collaboration with local authorities are helping businesses to implement Food Safety Management Systems. This could be the positive way forward for Ghana. Changes are difficult but human health is a costly resource that cannot be toyed with by any nation despite exiting pressures and priorities (FAO/WHO, 2005a). The food industry has started on a good path**.** On the part of SMEs, change is costly and most do not understand the risk associated with their activities. They are equally unable to afford a specialist service thus these will require government's special interventions in forms of sponsored training, publicity and other means of awareness creation. It must however be understood that in a deregulated environment, with uneducated consumers, the development and maintenance of self-regulation will not exist. There is therefore the need for increased public awareness on good hygiene and food safety practices consumers should look out for. Every nation has regulations that are supposed to protect its people against unsafe practices in food production, and the existing agencies needs to be equipped to enhance control.

2.3.2 *Institutional food service and safety of food served*

"Catering is the preparation, storage and where appropriate, delivery and serving of food for consumption by the consumer at the place of preparation or at a satellite unit'' CAC (1993). There are the commercial and institutional types of food service. Commercial types are mostly profit oriented and hence customer needs and service is paramount. These include hotels, restaurants, fast food outlets, cafes, bars, public houses, leisure centers, country clubs, health spas and travel catering (Marzano, 2010). The institutional services on the other hand are mostly nonprofit oriented and operate the meal service in support of other institutional objectives. Institutional food services serve a relatively large number of same clients on a regular basis and ensuring food safety is important. These institutions include hospitals, long term care homes, business and industry, day care centers, schools, colleges and universities food service (Marzano, 2010, Kwon, 2003). Despite available food safety systems, food service operators lag behind in the implementation of food safety measures (Santana, 2009, Kwon, 2003, Ryu *et al* 2011). In her study on cook-serve/conventional catering establishment in Italy, Marzono (2010) reported on unacceptable contamination of food contact surfaces and recommended the implementation of HACCP and development of standards for time and temperature control of foods in cook-serve kitchens. Conventional or cook-serve food services are associated with quality and fresh foods as foods are cooked from scratch mostly and served soon after preparation. However it is also related with intensive labour requirement with food safety decisions being made in short periods of time which might not help with consumer safety. Youn and Sneed (2003) reported that out of 20 foodborne outbreaks reported to the Center for Disease Control and Protection (CDC) 8 were associated with school meals in 1997 in the US. According to Santana (2009) in 2005, 11.6% of documented foodborne disease outbreak in Brazil were from schools. Nicholas *et al* (2002) reported improper storage, holding temperatures and food contamination by food handlers as the most commonly reported food practices that led to 604 food disease outbreaks in schools resulting in 49,963 illnesses, 1514 hospitalisation and 1 death in the US from 1973 to 1997. School food service staff in Benin studied by Bankole *et al* (2012) had high levels of potential pathogenic bacteria on their hands and nose which could be a health risk to students as methods of food handling by vendors could not eliminate those identified hazards.

According to Codex Alimentarius Commission (1993), mass catering services have been associated with;

1. Food poisoning epidemiologically
2. Operations considered hazardous due to the way food is stored and handled.
3. Outbreaks associated with large numbers of people.

   Another research conducted by the Food Standard Agency (2006) in UK on Management risk factors associated with foodborne diseases outbreaks within the catering industry in England and Wales reported;

1. Inadequate cooking and reheating
2. Cross contamination from raw to cooked
3. Inadequate refrigeration of cooked foods and
4. Inappropriate storage as some of the identified practices by catering facilities that bring about food safety failures.

The responsibility of managing food safety and ensuring consumer protection rest with the business whatever its size (Mayes and Mortimore, 2001)

2.3.3 *School meals in Secondary Schools*

Students in boarding schools depend on school food service for their meals (Afoakwa, 2005) although there might be other limited sources from registered and unregistered food vendors on site. This dependence calls for stringent measures on safety as any deviation could be detrimental to the whole school community. Some of the issues raised concerning sanitation in secondary schools in Ghana included limited facilities, lack of washrooms and changing rooms for kitchen staff. Most schools used multiple sources of water, 74.6% of schools in the region had pipe-borne water, 18.3% used external supply (Tanker service), 49.3% used boreholes and 2.8% were reported to be using rivers/streams which is being discouraged and the Ministry of Educations has been asked to discourage its use (Afoakwa, 2005). Raw material sourcing is reported to be mainly from the local market, private suppliers or from farm to gate, a characteristic of most SME's (Mayes and Mortimore, 2001). About 60-100% of schools in the regions use firewood in cooking. There is thus a limitation on the part of food handlers in putting up good hygiene practices not only in terms of knowledge but infrastructural and other physical burdens as well. Lack of manpower and the need to manage multi task is another problem for small scale enterprises (Marzano, 2010). However as mentioned, ensuring food hygiene in an area where there is limited means promotes safety much more than in one where there is abundance of facilities with hygiene thrown to the background. Food operators in school kitchens in Ghana did not consider food safety as a problem in their operations (Afoakwa, 2005). This is typical for most small scale and less developed enterprises, however food poisoning cases keep rising and food safety measures have become necessary to improve on local practices towards safer meals in schools. The onus lies on the legislature, government agencies in charge of food safety and other health institutions to create the awareness.

2.3.4 ***Legal requirements and school catering services***

Enforced regulations compels enterprises to comply with good practices (Mensah, 2011) The laws in countries ensure that customers are provided with wholesome food that is not injurious to health, given the food that is of quality demanded and not deceived in any way as per the information provided about the food. Food producers and food service providers are held responsible by law for any breach in this agreement, knowingly or unknowingly and are therefore to have in place systems that ensure safety as is reasonably possible and must practice due diligence. Penalties include fines and imprisonment or both depending on the gravity of the situation.

2.3.4.1 *Food and Drugs Law in Ghana (PNDCL 305B 1992)*

The Law on foods has 10 sections arranged as below.

1. Prohibition against sale of unwholesome food
2. Food offered as a prize
3. Deception of consumers
4. Standards of foods
5. Prohibition against sale of poor quality food
6. Manufacture of food under supervisions (6A Mandatory fortification of salt)
7. Sale of food under unsanitary conditions
8. Food unfit for human consumption
9. Penalty and defense
10. Closure of premises.

Thus the production of food not fit for human consumption, food that has in or on it a harmful substance is an offence. The harmful substance might not have an immediate effect but also a cumulative effect by taking in ordinary amounts (Section 1).

Food that is produced in an unsanitary premises and also without the presence of a supervisor with the appropriate knowledge and qualification to ensure the purity and wholesomeness of the food is an offence, Section 6 and 7 and Section 106 of the 2012 Public Health Act 851 (FDA, 2012).

Food that is quality is described as being aesthetically acceptable, nutritious and safe to eat. When food has the nutritional and aesthetic gratification but causes injury to the health of the consumer it cannot be said to be quality food. School kitchens responsibility in providing wholesome food for students is obligatory as students indirectly pay for the services rendered. This research seeks to ascertain the possible incidence of foodborne illness in schools and the effect of current hygiene practices of kitchen staff on food safety.

2.4 Food hygiene training for food personnel

In their evaluation of education on skill acquisition Verhaest and Omey (2009), mentioned that workers with low level of formal education are more likely to receive no training at work since their jobs are assumed to be less skillful. Managers and owners of enterprises have the dilemma of spending on training of staff after which they leave for greener pastures (staff turnover) and the development of staff for improved productivity (Coff, 1997). Food hygiene training on the other hand is a legislative requirement and staff are trained to ensure safer practices although the level or position of the individual could determine the volume and training requirements (Kwon, 2003). Barriers preventing food safety practices among small scale enterprises (SME's) are lack of understanding of food safety requirements and principles and the illusion of control (Panisello and Quantick, 2001, Afoakwa, 2005). Thus food handlers have the idea that their existing practices are safe as nobody has been killed and also they eat food produced on the premises and will not jeopardize the health of their consumers or themselves. However food service operators are reported of having reactive attitude in dealing with food safety risks rather than following risk preventive and controlled procedures. According to Taylor, (2008), kitchen staff in small scale enterprises including welfare hospitality work basing food safety standards on experience, common sense and lack (Taylor, 2008). There is also lack of motivation due to the absence or low external pressure from the legislature and consumers for evidence based food safety measures specifically in Ghana. Others include lack of suitable resources and facilities and management commitment (Ababio *et al, 2012*, Panisello and Quantick, 2001). Both internationally accepted food safety standards and private ones emphasis the importance of training and development of HACCP systems in food business for people who have potential impact on the safety of food for human and animal consumption. Whilst some authors including Santana *et al*, (2009), Bryan *et al* (1992), Hwang *et al* (2001) and Henriod and Sneed (2004) have reported on the positive association of training protocols and good hygiene practices of individuals, others report on the lack of evidence, and claim that presence of food safety management systems based on HACCP principles have no link to reduced risk raising the question on the appropriateness of training courses and the dependence of businesses on paper as proof of due diligence (Egan *et al*, 2007 Ehiri *et al* 1996). Soares *et al* (2012) reported on no association between the knowledge, attitudes and practices of food handlers and the presence of pathogens on their hands. Kwon (2003) reported that only 7.7% of his respondents recorded checking internal temperatures of food when 23.7% knew that it was the safest way to check doneness of ground beef products. He added that whilst 90% knew that cutting boards must be sanitized after cutting raw meat, only 20% complied with the procedure. Pilling *et al* (2009) in their work on evaluating the effect of food hygiene training in a mandatory environment and in areas where only managers had training reported no significant difference among food handlers in these restaurants. Success of food hygiene training of food handlers in schools is mostly influenced by age, level and type of educational background, previous information about the HACCP system, level of development in the area, training structure and participants' preparedness to learn. Training should therefore be job specific thus enabling staff to perform their duties responsibly after receiving adequate instruction. Food hygiene and safety trainers should put in structures that tackle both technical and behavioral changing needs of staff. Kelly and Markovska (2012) recommend that education and training programmes need to be scientific and competence based, effective and fit for purpose based on the real needs of the food business and the food industry.

2.4.1 *Importance of training as a management practice in school kitchens*

Training is relevant in food safety as it brings about behavioural change among trainees once their environment is equipped. Gilling *et al* (2001) added that training will only be effective if its outcome changes the way participants think (awareness and understanding), feel (attitude; agreement, self-efficacy, outcome expectance and motivation) and behave (behavoural- cueing mechanisms, competence, environmental, guideline and external factors). According to Eghan *et al* (2007), training in food hygiene should target behaviours that are likely to result in foodborne illness. Constant supervision on the part of supervisors is necessary to keep staff on their good practices knowledge acquired. Absence of the necessary tools and equipment as reported by Donkor *et al* (2009) could be a deterrent to behavioural change. On the contrary Feglo *et al* (2004) recommends training and surveillance as paramount in areas where cost of establishing and designing acceptable infrastructure and utilities could be ages before standards are put in place. Marzona and Balzaretti (2011) on their work on food safety in commercial catering reported that after a year of accepting and implementing guidelines, non-compliant samples which originally amounted to 55% fell to 30% after a year which was attributed to sensitization of operators on risks associated to their preparation which led to adoption of workflows and suitable temperature and time management of their operations. Santana *et al* (2009) reported on schools that were classified as poor or medium in their food hygiene and safety practices upgrading to good and excellent levels after GMP training. Temperature of cooked food and time monitoring equally improved to > 62 °C and with a food waiting time of only 30 minutes for medium hygiene category schools although poor schools did not still meet the standard. Mean score of food handler's hygiene awareness are reported to increase after training in basic hygiene (Ababio, 2011) signifying increased knowledge.

2.5 Food Hazards and sources of contaminants

It may not for now be known for sure what percentage of deaths and diseases aside food poisoning and gastro intestinal disease reported are caused by food hazards due to limited knowledge and awareness, low reportage and lack of facilities to investigate. Major contaminants or food hazards as sources of disease include *Salmonella, Campylobacter, Clostriduim,* Hepatatis E, *Vibrio, Listeria,* Enterohaemorrhagic *E. coli,* pesticides, metals, persistent organic pollutants, toxic chemicals, organic pollutants and biologically organic causing transmission derived toxins (WHO, 2007). Chemical contaminants have been implicated in food poisoning (Balzaretti *et al*, 2009). Melamine and dioxin contamination and detrimental effects have been reported. Physical hazards could cause injuries to unsuspecting consumers and could be detrimental. Chemical and physical contaminants are mostly related with sensory issues and hence easier to detect leading to hazard isolation and or food rejection. Food microbial levels however have extensive documentation on the economic importance of spoilage and pathogenic bacteria to the food industry and the consumers. Microorganisms in food include mould and yeast, protozoa, viruses and bacteria. These organisms have some useful purposes in the food industry but this research looks at the availability of some food spoilage and pathogenic bacteria and yeast and mould. Bacteria contaminants are of much importance to the food industry due to their ability to grow in numbers to disease causing levels, production of toxins and their selective mobility. Again food pathogens could be present in food and yet have no effect on the sensory characteristics of the food that could lead to rejection. In Ghana over 25% of all deaths in children is reported to be caused by poor food hygiene issues and an overall 65,000 deaths in the country annually is attributed to foodborne diseases and its effects (MOFA/World Bank, 2007).

Studies on bacterial composition on surfaces in production areas are diverse including persistent house flora and contaminants from raw materials and humans. Langsrud *et al* (2012) isolated bacteria in food production environments and persistent ones after cleaning and sanitization included *Pseudomonas, Staphylococcus*, and *Acinetobacter.* Other pathogens isolated included *Salmonella, Bacillus, Shiga toxigenic E. coli, Listeria monocytogenes* and *Clostridium.* Some of which have a competitive advantage of survival more than other bacteria due to biofilm formation and ability to survive under unfavourable conditions for most microorganisms.

Personnel handling food could also be a major source of food contamination. Laboratory analysis of swabs from food handlers working in school canteen's nose, mouth and hands had high levels of gram positive bacteria (47.54%) of which *Staphylococcus aureus* was 44.83%, followed by *Enterobacteriaceae* (29.51%) of which *Klebsiella pneumonia* was 38.89% raising questions about the hygiene practices of the food handlers (Bankole *et al*, 2012). Other pathogens isolated included sulphite reducing *Clostridia*. Effective hand washing procedures alone has been identified as a useful procedure in reducing microbiological contamination from staff (Tan *et al* 2013). Watutantrige *et al* (2012) reported on the importance of hand washing with soap and opined that medical students who washed hands with soap after using the toilet had bacterial load on hands reduced significantly ($p<0.05$) than those who washed with only water. Social hand washing (plain soap and water) is recognised by WHO as the most effective and inexpensive way to prevent transmission (WHO, 2009). On the other hand Kampf and Kramer (2004) reported that plain soap and water could only remove transient organisms and organic matter but not micro flora of the hands and recommended addition of antiseptics.

All food raw materials are sources of food hazards based on farm practices, food handling through transport and distribution, processing and storage. This is due to the contact with nature including soil, water and other living organisms including man. Food therefore needs to be handled with care and hygienically to prevent, eliminate and or reduce microbiological hazards to levels that cannot be injurious to health when consumed. Cooked food is expected to have low levels of microbiological contaminants and possibly void of food pathogens if all hygiene practices were in place during the preparation. A high level of microbiological hygiene indicators therefore stipulate the nearing of shelf life of the food or a possible cross contamination after cooking. In their work on food safety by food vendors on Koforidua Polytechnic campus, Amissah and Owusu (2012) reported of the absence of *Salmonella* in rice and soup meals sold on their campus. Levels of *Staphylococcus aureus* in waakye (cooked rice and beans) was 2 Log_{10} $CFUg^{-1}$. Mensah *et al* (2002) on their report on food microbiological safety in food sold in Accra among food vendors reported of *Staphylococcus aureus* levels of between 3.7 Log_{10} – 4 $Log_{10}CFUg^{-1}$ in rice meals whiles *Salmonellae* was absent. Nyarko *et al* (2011) also reported of absence of *Salmonella* in roasted fish but a significant difference between Aerobic Colony Count (ACC) of cooked fish at the manufacturing site and those transported to the market with ACC levels of products on the market exceeding 6 Log_{10} CFU g^{-1} which is above the acceptable limits for cooked food for the Ghana Standard Authority (GSA). They reported of the absence of *Staphylococcus aureus* in grilled fish in Tema-Ghana but high levels of yeast and mould above the acceptable limits of 4 Log_{10} $CFUg^{-1}$ of the GSA. *Bacillus cereus* in cooked rice was however not investigated even though high levels (5 Log_{10} $CFUg^{-1}$) in cooked cereals especially rice and pasta have been reported to cause emetic syndrome and on contaminated vegetables and meat causing diarrhoea syndrome lasting for a day among sufferers (Health Protection Agency, 2009). In a food hygiene intervention research among public schools in Brazil, Santana *et al* (2009) studied the effect of food hygiene training on the food hygiene practices including hand hygiene, temperature and time control and food microbiological contamination. They reported of high ACC in meals in a school categorized as poor for food hygiene standard but absence of coagulase-positive *Staphylococcus aureus* and thermotolerant coliforms. Surprisingly a school which was categorized as excellent had the presence of thermotolerant coliforms in their meals which was attributed to the raw nature of the food or possible contamination by food handlers who also had poor hand hygiene at the time of the study. A school categorised as medium in hygiene standards also had coagulase-positive *Staphylococcus aureus* in rice and meat ball meals and this count was higher than their ACC count and also higher than their national acceptable levels of 3 Log cycles for coagulase positive *Staphylococcus aureus* in Brazil. High ACC was reported on utensils which came into direct contact with food and some food handlers had *E. coli* on their hands signifying poor hand hygiene even in an excellent category school which during auditing had the requisite soap and antiseptic agent for hand washing. Santana *et al* (2009) reported of a reduction of 3.5 Log cycle of ACC count of meals, 1.6 in serving ladles, 3.7 Log in serving spoons and 3.5 Log cycles in serving plates and absence of pathogens in the school that was categorized as poor for hygiene standards after GHP intervention.

2.5.1. *Microbiological contaminants and food safety*

Total viable count or aerobic colony count is an indication of the quality of food under investigation. Higher levels equal to or exceeding 5 $Log_{10}CFUg^{-1}$ has been reported as product nearing spoilage (old) or unsatisfactory (gross contamination) for food cooked immediately prior to sale or consumption (HPA, 2009). The Ghana Standards Authority acceptable limit is reported to be 6 Log_{10} $cfug^{-1}$ for cooked food (Nyarko *et al*, 2011). The current ACC level for cooked rice and related products was 4 Log_{10} CFU g^{-1} (GS 955, 2013). However raw and ready to eat foods including salads and uncooked sea food could have high counts due to processing methods. Organisms could be of the natural flora of the food sampled or from cross contamination after processing. ACC however is not used as food safety indicator (Solberg *et al* 1990).

Enterobacteriaceae have a broad ecological distribution, some species have environmental reservoirs including the food producing environment, and others are considered as obligate inhabitants of warm blooded animals including humans and as such give an indication of general hygiene conditions of the food premises. Among the important genera included as enterics are *Escherichia, Salmonella, Shigella, Klebsiella, Serretia, Proteus, Yessinia, Erwinia* and *Enterobacter.* They are identified to dominate food producing equipment and are indication of faecal contamination from raw material or personnel (Langsrud *et al*, 2012). Enterobacteriaceae are reported not to be able to grow well in low temperature environments and other harsh anti-bacteria treatments and hence survival in food is associated with high contamination frequency in a favourable environment. Standard levels in food contact surfaces according to Henriod *et al* (2004) is <1.0 Log CFUcm-^{2}.

Coliforms, a sub group of Enterobacteriaceae that ferment lactose producing gas and acid at higher temperatures, are environmental contamination indicators in ready to eat foods although there are limitations (Christison *et al* 2008) as these bacteria naturally occur on fresh produce including vegetables. These are heat sensitive and their presence in cooked food is an indication of post processing contamination (Mead, 2007). Types that can grow at high temperatures (44-45.5℃) including *Esherichia coli* are faecal coliforms and an indication of recent faecal contamination. The Ghana Standard Authority acceptable levels for cooked food is 1 Log $_{10}$ CFU g^{-1} (Nyarko *et al*, 2011)

Escherichia coli are members of the *Enterobacteriaceae* and inhabits intestinal tract of humans and warm blooded animals, they are thus associated with faecal contamination. The presence of *E. coli* does not convey an automatic direct correlation with the presence of major enteric pathogens and absence does not also exclude the presence in food of non-enteric pathogens and other enteric pathogens including *Salmonella* (ICMSF, 2002) They are indicators of cross-contamination (Christison *et al* 2008) either from food handlers, unhygienic contact surfaces or poor storage temperatures. Figures in ready to eat foods above 2 Log_{10} CFU g^{-1} are unsatisfactory (HPA, 2009).

Salmonella is one of the leading causes of foodborne related deaths and hospitalization in the US and Europe (Center for Disease Control, 2011). A food pathogen that has the ability to form biofilms on surfaces with possible cross contamination of food from equipment and surfaces causing several outbreaks. It is a predominant foodborne outbreak identified vehicle of infection in the England and Wales mostly from ready to eat food (Christison *et al*, 2008) There are reports of individuals food vendors carrying typhoid causing *Salmonella* in the Ashanti Region of Ghana (Feglo *et al*, 2004). *Salmonella* due to its pathogenic nature is not expected in food samples and absence in 25g of food sample is a safety requirement.

Staphylococci are gram positive cocci, facultative anaerobes that are halophytic. They are mainly found on the skin of humans and the strains *S. aureus* cause foodborne disease and produces toxins. *Staphylococcus aureus* occurs widely on the skin and mucous membrane of warm blooded animals and can be introduced in food production environment from personnel and raw materials. Their presence in ready to eat food may be a result of improper handling, cross contamination and poor temperature control (Christison *et al*, 2008). It has high level of tolerance for desiccation and survives well in halophytic environments. *Staphylococcus aureus* is reported to be able to withstand disinfection through formation of biofilms (Langsrud, 2012) Higher levels of vegetative cells, 5 - 8 Log_{10} $CFUg^{-1}$ are required to produce enough toxins to cause food intoxication (Blackburn and McClure, 2009), thus growth of the organism in food is required. According to HPA (2009), levels above 4 Log_{10} CFU g^{-1} are unsatisfactory and could be a potential source of injury to the consumer. *S. aureus* is reported to have a short generation time (102-126 minutes) in cooked rice and toxin production rate is reported to be highest in cooked meals at 45°C (Dablool *et al,* 2014). Temperature and time study of *S. aureus* contaminated cooked rice samples in Saudi Arabia indicated higher positive growth at an average temperature of 53.3 ℃ (41.6%) than at 66.4℃ (16.7%) (Dablool *et al,* 2014). *S. aureus* has a short incubation period of 2 to 4 hours and is reported to present relatively mild infection symptoms. Although food poisoning are mostly recorded for *Staphylococcus aureus*, through the ingestion of enterotoxins preformed in food, other species that are both coagulase- positive and coagulase- negative staphylococci are also reported to produce enterotoxins but with less evidence of poisoning implication.

Bacillus are gram positive endospore forming rods with spores being highly thermophilic and can withstand harsh conditions including absence of nutrients and water disinfection. Can cause both foodborne disease and food spoilage. They are present in soil, dust and plant products. Many species and strains can produce extracellular enzymes that hydrolyze food nutrients. The satisfactory and unacceptable levels or potentially hazardous levels of vegetative *Bacillus cereus* in food as reported by the UK Public Health Laboratory Services are <3 $Log_{10}CFUg^{-1}$ and >5$Log_{10}CFUg^{-1}$ respectively (Blackburn and McClure, 2009) with acceptable levels between 3 - 4 $Log_{10}CFUg^{-1}$. Food poisoning symptoms are reported to be relatively mild and of short duration and include both emetic and diarrheal types. The diarrheal form occurs within 8-16 hours after ingestion of mostly proteinaceous foods including milk, meat and vegetable dishes, sauces and soups and desserts (Batt, 2000), with an infective dose of 5 - 7 Log10CFUg^{-1} and symptoms last within 24 to 48 hours. Emetic syndromes have incubation period of 1-5 hours and last between 6 and 24 hours and require 5 - 8 Log_{10} CFU g^{-1} of food mostly farinaceous type of food including rice, pasta, noodles and pastry although lower levels have been reported by other authors (Granum and Baird- Parker, 2000, Gaulin *et al* , 2002).

Yeast and moulds in food may produce toxins with repeated dosage causing delicate organs damage in the human body. Spoilage of food is another characteristic particularly of moulds which is of an economic importance to the food industry. The mode food is harvested, transported and stored collectively have an effect on the level of mould growth. Environmental contamination equally affects food during preparation and storage. The level of yeast and mould acceptable in cooked foods according to the Ghana Standard Authority's GS 955 (2013) is 3 $Log_{10}CFUg^{-1}$. With food contact surfaces, yeast and mould levels have not been determined in Ghana. The Agriculture, Food and Rural Development in Manitoba in their 2014 Validation of GMP programme have a guideline of 1 Log_{10} CFU cm^{-2} for yeast and mould levels after effective cleaning programme. This would be used as the bench mark for the research in Ghanaian schools.

2.5.2 ***Effect of staff hygiene practices on microbiological quality of ready to eat foods***

Microbiological safety and quality of foods are determined by the kinds and number of microorganisms occurring in them. Bacteria, yeast, moulds and viruses are important in food due to their ability to cause foodborne diseases and also spoil food although some are of great benefit to the food industry. Whilst all of them can cause food spoilage yeast on the other hand does not cause foodborne disease. Bacteria is the most ubiquitous organism among the other mentioned microorganisms and can survive conditions that are harsher for the rest. The type of organism, their numbers and rate of exposure to the consumer and the type of consumer all determine the magnitude of the risk. There are acceptable limits of some identified microorganisms that go to certify whether food is acceptable, satisfactory or not satisfactory. Changes or an increase in the microbiological load in food due to contamination from the environment including humans, equipment and other contact surfaces and or poor storage temperatures increases the risk of food spoilage and food borne diseases. These factors, collectively called food hygiene practices have extensively been studied by researchers including Bankole *et al*, (2012), Soares *et al* (2012), Feglo and Sakyi (2012), Rodriguez-Caturla *et al*, (2012), Santana *et al*, (2008), Youn and Sneed (2003) and Johnson *et al*, (2008). Poor hygiene practices prominently mentioned among researchers to be the cause of increased microbiological load and foodborne diseases include, poor hand washing regimes, poor temperature control of cooked food before service, cross contamination and raw ingredient sourcing as shown in Table 2.

Table 2. Contributing factors to general foodborne disease in England and Wales from 1992-1996

	Outbreaks	
Contributing factors	**Number**	**Percentage (%)**
Temperature misuse		
Improper heating	211	39.8
Improper reheating	14	2.6
Inadequate storage	170	32.1
Preparation too far in advance	15	2.8
Inadequate thawing	10	1.9
Total	420	79.2
Inadequate handling		
Food handler	48	9.1
Cross-contamination	118	22.3
Total	166	31.3
Inadequate environment		
Insufficient hygiene	15	2.8
Inadequate facilities	5	5
Total	20	3.8
Raw material		
Raw ingredient	116	21.9
Infected animals	3	0.6
Total	119	22.4

***Percentages are based on total number of outbreaks (n=530). Panisello *et al*, (2000).**

Comparative study of food microbiological safety and hygiene of food environment and hygiene practices has shown a positive correlation (Adolf and Azis, 2012, Santana *et al*, 2009). In Ghana, researchers have reported on high levels of total bacteria count (> 5 Log_{10} $CFUg^{-1}$) and presence of potential pathogenic microorganisms in food prepared in commercial kitchens relating them to existing poor hygiene practices (Feglo and Sakyi, 2012, Addo *et al*, 2007). Hand washing with soap (social hand washing) which is recognized as effective, an inexpensive way to prevent transmission of diseases (WHO, 2009), better than water only hand washing and comparable to costly antibacterial products (Oranusi *et al* 2013, Watutantrige *et* *al*, 2012) but not properly adopted by food handlers was responsible for 31% of foodborne diseases in England and Wales (Table 2). With the absence of suitable sanitation facilities, potable water, washrooms and changing rooms for staff (Afoakwa, 2005), schools in Ashanti Region could be exposed to hygiene challenges that affect food safety. In the US and India, Sumner *et al* (2011) and Anuradha and Dandekar, (2014) respectively reported of food handlers reporting to work whilst suffering from diarrhoea and vomiting symptoms. Without existing policies to prevent sick staff from handling food and the awareness of these through training and strict supervision food handlers could be transfer foodborne diseases to consumers.

2.6 Analytical Microbiology of food and food environment

The presence of disease causing microorganism in food and other related quality indicators have been extensively studied in commercial food service settings. Addo *et al* (2007) reported of the absence of *Salmonella*, S. *aureus and E. coli* in jollof rice and other cooked meals in hotels in Accra. ACC was 3.52 $Log_{10}CFU\ g^{-1}$ in jollof rice and 35% of food contact surfaces had non-thermotolerant coliforms. A similar exercise on street foods in the Ashanti Region by Feglo and Sakyi (2012) showed that a farinaceous food (macaroni) had mean ACC of 5.58 $\pm$ 0.97 $Log_{10}CFUg^{-1}$ thus above the national acceptable level of 4.0 log_{10} CFU g^{-1} (GS 955, 2013). Isolates obtained from sampled meals included predominantly coagulase negative *Staphylococcus aureus, Bacillus spp*, and other Enterobacteriaceaes including *E. coli*. Santana *et al* (2009) similarly reported of > 5 Log_{10} $CFUg^{-1}$ in macaroni meal in Brazilian schools but also reported of 0.2 – 3.5 Log reductions in the schools cooked meals after a GHP intervention. Food contact surfaces cleanliness directly affect food quality due to cross contamination and other indirect contacts via kitchen staff. The level of cleanliness of these surfaces has direct correlation with food microbiological quality (Marzano and Balzaretti, 2013). Different food industries have varied baseline of established normal background bacterial counts through series of sampling results. According to the Provincial Health Services Authority (2010), clean food contact surfaces in restaurants and other RTE services are effective if ACC values are <1.65 $Log_{10}CFUcm^{-2}$, contaminated with 2.15-2.41 $Log_{10}CFUcm^{-2}$ and very contaminated with >2.41 $Log_{10}CFUcm^{-2}$. Sneed *et al* (2004), Santana *et al* 2009, Rodriguez-Caturla (2012), Osimani *et al* (2011) and Marzano and Balzaretti (2013), gave advisory standards for ACC, total coliforms and *S. aureus* count on food contact surfaces after effective cleaning as <1.3 Log_{10} CFU cm^{-2}, 1 Log $_{10}$ CFU cm^{-2} and < 1 Log $_{10}$ CFU cm^{-2} respectively. The latter will be used as the bench mark for cleaning effectiveness in this work. The Ghana Standard Authority has acceptable microbial levels for selected cooked meals (Table 3).

Table 3. Microbiological limits ($CFUg^{-1}/CFUcm^{-2}$) adopted for the definition of acceptability of food, work surfaces and operators hands

Food	**ACC**	**Total Coliforms**	**Yeast and Moulds**	***S. aureus***	***B. cereus***	***Salmonella***
Cooked and ready to eat meals (g^{-1})	10^4	10^2	10^3	10^2	10^2	Absence in 25g
Work Surfaces	*20	*10	10**	*10	-	N/A
Operators hands (cm^{-2})	-	*10	10**	*10	-	N/A

N/A= not applicable *Information on advisory standard from Solberg *et al* (1990) ,Sneed *et al* (2004), Santana *et al* 2009, Rodriguez-Caturla (2012), Osimani *et al* (2011) and Marzano and Balzaretti(2013). All other information from Ghana Standards Authority. GS 955: 2013, comparable to ICMSF (2005)
**** Guideline for yeast and mould levels post cleaning. Manitoba Agriculture, Food and Rural Development (2014)**

These will be the acceptable bench mark for microbiological standards for school meals in Ashanti Region.

Although *Listeria, Campylobacter, Salmonella* and *E. coli* 0157 are pathogens of most concern in food safety (Pennington, 2014) they cannot be used for food trend analysis as they could be present and yet not identified by current technology, Solberg *et al* (1990) added that the testing of pathogens was of limited value since the illness-causing dose was imprecise. Hence food quality and other hygiene indicators with relatively milder symptoms including ACC, total coliforms, yeast and moulds, *Staphylococcus aureus, Bacillus cereus* were chosen to investigate the effect of hygiene practices on food safety as they are useful for trend analysis.

Staphylococcus aureus and *Bacillus cereus* both produce toxins and *Bacillus cereus* produces spores and with relatively short incubation periods, both could be food safety risks in a poor hygiene environment. *Salmonella* has already been mentioned by Feglo and Sakyi (2012) in Ghana to be present in street foods and on food handlers in Ashanti Region. In Indian hospitals 37% of food handlers were reported to work when suffering from gastroenteritis (Anuradha and Dandekar, 2014) affecting the control of foodborne infections in the work place. Some staff in the United States are also reported to be likely to report to work when sick with diarrhea and vomiting symptoms to avoid cut in wages (no sick leave with pay policy) and during busy periods at the work place as reported by Sumner *et al* (2011). They reported that 11.9% of 491 food handlers answered on the affirmative that they had reported to work at least twice within a year with diarrhea and vomiting symptoms. Other related benefits including free meals at work might be a factor in less developed and developing countries whilst lack of training and awareness in food hygiene could also be contributing factors in lack of risk avoidance. There is zero tolerance level for *Salmonella* in 25g of ready to eat meals (GS 955, 2013) and these would determine the safety of food in school kitchens in Ghana.

CHAPTER 3

3.0 METHODOLOGY

3.1 Research strategy

This section introduces the research aims and objectives, approach and strategies the research was based on (Fig.3), the significance and limitations of the research. The population studied, materials, equipment, analytical methods and statistical tools used for analysis and reasons for their choice were also given.

3.1.1 *Research Aims and Objectives*

The researcher sought to study the current hygiene practices and microbiological quality and safety of food in Senior High Schools in Ashanti Region of Ghana towards the adoption of suitable international interventions, Good Hygiene Practices (GHP) and Hazard Analysis and Critical Control Point (HACCP) and to ascertain differences in the two interventions towards sustainable food safety practices and consumer safety. Data could be used by policy makers in taking appropriate decisions on food safety objectives for the country.

3.1.2 *Objectives*

I. To investigate the possible incidence of foodborne diseases among students in SHSs in Ashanti Region.

II. To comparatively evaluate kitchen hygiene standards, awareness and practices among staff in SHSs kitchens and compare with a standardized system.

III. To conduct microbiological analysis of food pathogens in meals served in SHS canteens in Ashanti Region of Ghana.

IV. To train sampled school kitchen staff on Good Hygiene Practices based on identified needs and evaluate the effect of training on their hygiene and food safety practices.

V. Investigate how HACCP could be used to control food safety in SHS food services.

3.1.3 *Scope and limitation of the thesis*

This thesis concentrated on evaluating the hygiene practices in SHSs kitchens in the Ashanti Region of Ghana and the effect of GHP and HACCP interventions on food safety and hygiene practices of kitchen staff. Kitchen staff hygiene knowledge and practices, microbiological analysis of food samples, staff hand hygiene and cooking utensils after cleaning were evaluated. Water was not included in the analysis.

Other regions of the country were not included. The field work including GHP and HACCP implementation were conducted within 12 months (July 2013 to July 2014). There was limited time for frequent visits and reinforcement in the schools after HACCP due to schools vacating and the researcher had to leave Ghana for the UK.

HACCP study was conducted in five (5) schools after GHP training in eleven schools. This sample size for HACCP study was relatively small statistically.

3.1.4 *Significance of the study*

The research adds institutional food services food safety and hygiene practices information to existing known practices and effects from commercial food establishments in the country. It also creates a platform for researchers and other stakeholders to put equivalent focus in the forms of food hygiene monitoring, finance, training and provision of suitable facilities to institutional kitchens. The methods of introduction of GHP and HACCP and their respective effects are equally possible ways both commercial and institutional caterings in the country could use to upgrade their current practices to enhance food safety and to meet the legal requirements of food laws internationally. This involved an initial assessment (kitchen food hygiene audit, staff and student’s questionnaire administration) of the schools, kitchen staff hygiene practices and hygiene standards towards categorisation, after which two interventions in the form of GHP and HACCP were introduced.

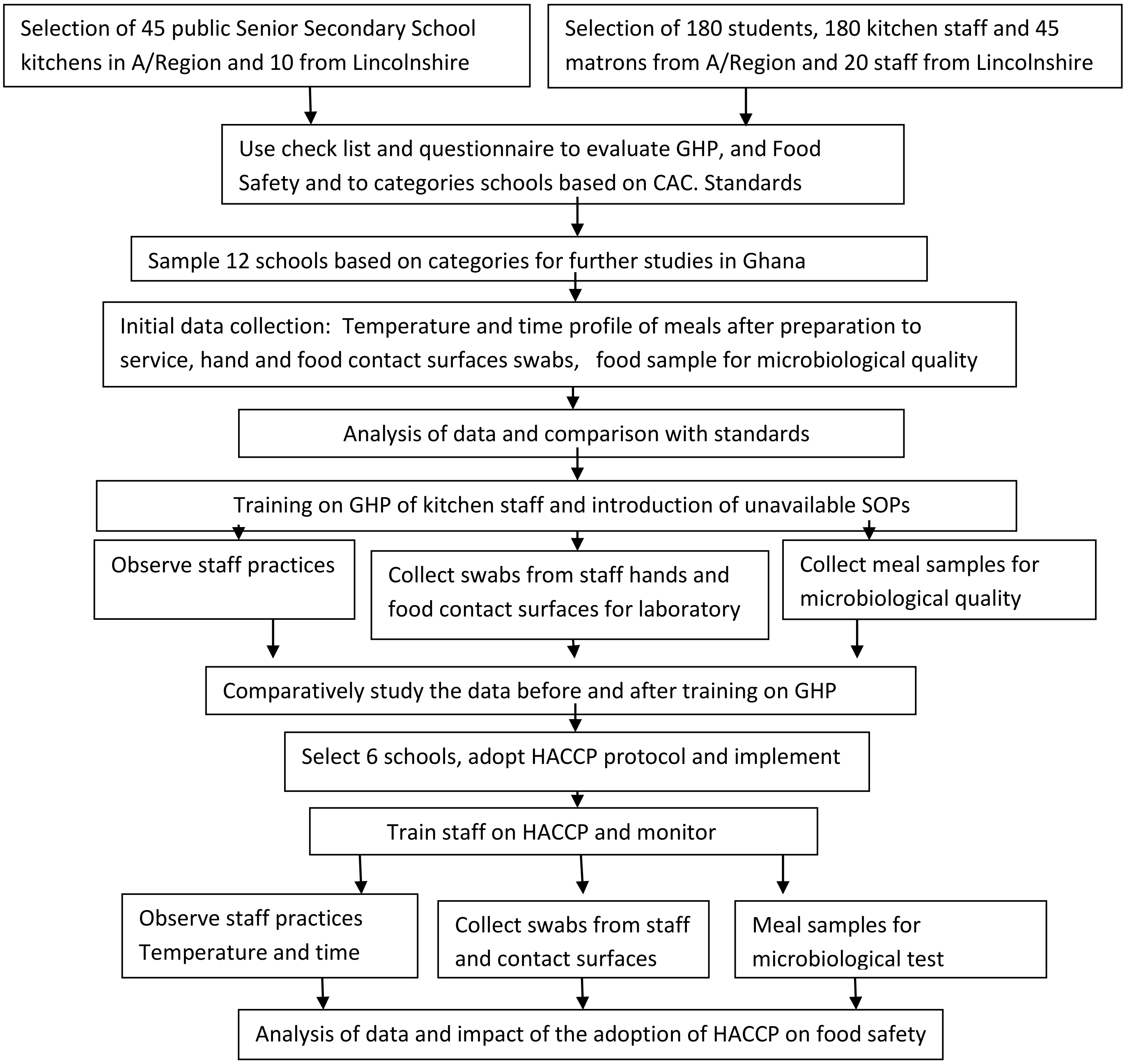


Figure 3. Flow chart on methodology used in the investigation

3.2 Research Approach

Staff hygiene scores, hygiene behaviour and their effect on food safety and quality were measured before and after each intervention. (Santana *et al* (2009). Comparisons were then made on the GHP and HACCP interventions.

3.2.1 *Experimental design*

The researcher used both Pre-test and post-test and survey means of studying and collecting data from the sampled population.

Pre test and Post test design

The pre-test and post-test were in the form of measuring changes in variables including food hygiene knowledge, personal hygiene knowledge, food safety practices (temperature and time control of Ready-to-Eat food, hand washing regime and cleaning effectiveness) and microbiological quality of food before and after GHP and HACCP interventions (Santana, *et al* 2009) from July 2013 to August 2014.

Survey

Questionnaires (Appendices 2 - 4) developed to ascertain the pre intervention hygiene practices and their effect on consumer safety was given to 4 Students, 1 Matron and 4 other Kitchen staff per school in Ghana. A total of 10 schools in Lincolnshire with 1 kitchen manager and 1 kitchen staff were used as a bench mark to comparatively study practices from a standardised system to non- standardised one.

Kitchen staff scores on personal hygiene requirement were scored on a Likert scale (Most likely, likely, don't know, unlikely and most unlikely) of 1 to 5 with a positive answer score of 5 and the wrong answer scoring 1. Whilst food hygiene knowledge test was a set of 14 questions with a total mark of 100% (Appendix 3)

A check list on auditing standard operating procedures available (Appendix 1) used by Santana *et al*, (2009) was used to categorise schools into excellent, medium, poor and very poor schools for further studies on their effect on food safety.

Validity of research results was strengthened by triangulation of data collection methods. Thus information to ascertain the food hygiene standards in the schools were gathered from three points of view; students and kitchen staff questionnaires (Appendices 2, 3 and 4 respectively), audits with observations (Appendix 1) and microbiological analytical work on food and food contact surfaces from kitchens.

Type of data and data distribution was analysed for an effective choice of analytical tool to give a coherent result using SPSS version 21.

3.3 Materials and methods

Equipment used

Hygiena Pro-clean (127412), Temperature probe (SRT-i100 SainSonic), Stomacher (MIX3011), Votex mix, refrigerator, incubator, water bath, Benson burner, microscope, autoclave, analytical balance, Hot plate, colony counter, petri dishes, inoculating loops and needles, spreaders, pipette, pipette tips, measuring cylinders, universal bottles, ice chest, test tubes, stomacher bags and swabs for environmental and staff hand hygiene sampling. Other personal items for training included projector, laptop, marker board and markers for writing, camera, washing bowls and water containers, hand washing soap (lifebuoy) and napkins and FSA DVD on Safer Food, Better Business (Version 3 2009 FSA/0662/0712) and a personal means of transport.

Culture media, Reagents and supplements

Culture media: Buffered peptone water (Oxoid CMO509), Plate count agar (Oxoid CMO325), MacConkey Agar (Oxoid CMOOO7), Brilliance *Bacillus cereus* agar (Oxoid CM1036) , Baird-parker agar (Oxoid, CMO275 and CM0961), Brain heart infusion broth CM1135, Rose Bengal agar (Oxoid CMO549) , Xylose Lysine desoxycholate Agar (Oxoid 326589), Bismuth Sulphite Agar (Oxoid CMO201), Triple sugar Agar (Fluka 44940), Lysine Iron (Oxoid CM381B), Nutrient Agar (Oxoid CMOO3), Peptone (Oxoid LPOO37), Tryptone (Oxoid LPOO42), Rappaport Vassiliadis with Soya(Oxoid CMO866).

Supplements: Chloramphenicol supplement (Oxoid SROO78E), Egg yolk tellurite emulsion (Oxoid SROO54C), Egg yolk emulsion (Oxoid SROO47C) and Polymixin B Supplement (Oxoid SROO99E and Lab M. X074).

Reagents: Rabbit coagulase plasma (TCS Biosciences CP6X3), Kovac's reagent (Pro Lab K17158), Indole reagent (Oxoid MBO209A), Gram stain kit (Bio Lab Diagnostics), API 20E (Biomerieux 20100), API Staph (Biomerieux 20500), Hydrogen peroxide (Ernest Chemist Ghana ECL1013), Oxidase reagent strips (Australia MBO266A) and ATCC *S. aureus* from Kumasi Centre for Collaborative Research.

All media, supplements, reagents and consumables were from the United Kingdom with the exception of Hydrogen peroxide and gram stain kit that were sourced locally. Locally approved detergents; key soap and lifebuoy (active reagent, Thymol and Active5) with hot water and or sanitisers (sodium dichloroisocyanurate 400 mg) from UK were used for cleaning and sanitizing during training.

3.3.1 *Population and Sampling*

Ghana has a population of 25 million distributed in 10 regions of which the Ashanti Region, the highest populated region in Ghana (2010 population censors) has 19.4% of the population (Ghana Statistical Service, 2012). There are 700 Senior High Schools in Ghana out of which 493 are public schools and the rest are privately owned (UNESCO, 2010, MoE, 2009). The Ashanti Region (Fig. 4) alone has 86 (17.4%) public Senior High Schools (MoE, 2009, Siaw and Nortey, 2011) and 41 private SHSs. SHS students' enrolment as at 2008/2009 in the country was 490,334 with the region taking 44.1 percent of this population. The region is the highest populated with high numbers of people with low educational status, a central trading zone prone to increasing food borne diseases (Osei, 2010) with low level of food hygiene and safety among food handlers (Ababio and Adi 2012).

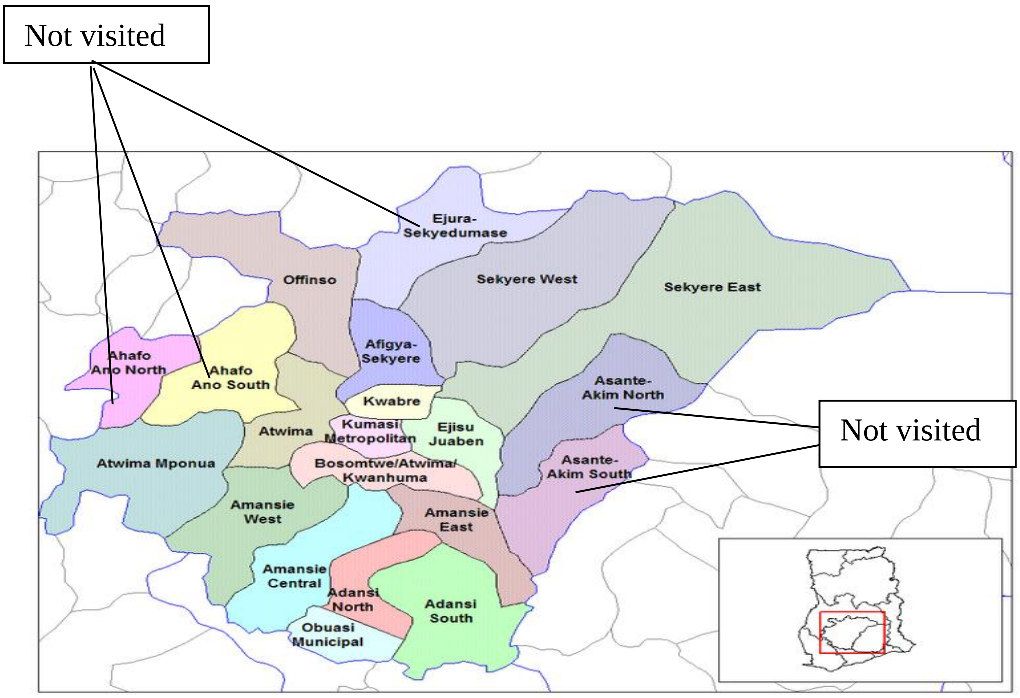


Fig 4. The Ashanti Region of Ghana (Wikipedia, 2006)

Permission letter to conduct the research was sought from the Regional Education Director of Ashanti Region through an introductory letter from the researcher's University/employer (University of Education Winneba Kumasi Campus). A letter signed by the Ashanti Regional Education Director introducing the researcher as a student conducting research in schools was taken to public boarding SHSs in the region by the researcher to seek permission from Heads of the institutions. Out of 58 (67%) schools visited 45 (52%) were available for the research. These 58 schools were spread throughout the Ashanti Region (Fig 4).

3.3.1.1 Schools and Kitchen staff from Ghana

The population for the study consisted of kitchen staff in Senior Secondary Schools in Ashanti Region of Ghana and students in the same environment. An initial number of 45 Schools, 180 kitchen staff and 45 matrons were randomly sampled out of the 86 public Senior High Schools (MoE, 2009) in the region for a preliminary study on existing hygiene practices in schools. For further microbiological laboratory work and Good Hygiene Practices training a subsample of 12 schools out of the 45 were selected based on the hygiene categories developed. That is all 4 schools within poor hygiene category, 4 from the good hygiene category and 4 from the medium hygiene were selected for further evaluation by comparing their pre and post training practices and scores. One school of the poor category dropped out from this leaving only 3. Further five (5) schools out of the 11 were then used for further training and the adoption of HACCP in schools based on school management willingness and availability as explained in Section 4.5. The effect of the intervention of HACCP on staff practices and food safety was assessed.

3.3.1.2 School and Kitchen staff Lincolnshire- United Kingdom

Permission to visit schools in Lincolnshire UK was sent around 10 randomly selected schools through the authorization of the researchers supervisor and Dean of Faculty. Questionnaires on availability of food safety management systems and staff hygiene practices were given to 1 kitchen matron and 1 kitchen staff each from the ten schools sampled from Lincolnshire to serve as a comparative study of hygiene practices from a standardised food hygiene environment. Two staff from two schools volunteered to participate making a total of 12 kitchen staff.

3.3.1.3 Students from Ghana

A total of 180 boarding students (first and second years) were randomly sampled from schools in the Ashanti Region of Ghana. Students consisted of first and second year boarding students as third years (final year students) had completed and left school. Each boarding student from each school from the population stood a chance of being picked for the study on investigating the incidence of foodborne disease in schools and students food hygiene awareness.

3.3.2 *Check List and questionnaire application*

The checklist was adopted to access information about the kitchens facility-design, utensils and equipment-maintenance, employee hygiene practices, quality of raw and ready to eat food, production flow, food handler practices and quality control. The form (Appendix 1) had five sections. The first section considered facility-design with 23 questions (K=10), section two on utensils and equipment-maintenance, was accessed with 10 questions (K=15), section three on personal hygiene of employee was accessed with 7 questions (K=25), section four on quality of raw and ready to eat food had 4 questions (K=20) and section five on flow of process/food handlers/ service and quality control was accessed with 14 questions (K=30). The score of each part evaluated (P) was calculated using the formula below.

$P = (TS/\sum_1 - \sum_2) \times K$

Where TS represents total of points obtained; $\sum_1$ represents the total number of possible points, $\sum_2$, represents the total number of points not applicable, and K is a constant ($\sum_K = 100$). The mean of the scores of the five parts was calculated as (P1 + P2 + P3 + P4 + P5)/10 and the kitchens were classified according to a scale: Excellent: 9.0-10.0, Good: 7.0-8.9, Medium: 5.0-6.9, Poor: 2.0-4.9, and Very poor: 0-1.9 adopted from Santana *et al*, (2012).

All the auditing and scoring of hygiene standards in schools were conducted by the researcher only.

Student's questionnaire (Appendix 2) targeted their food hygiene awareness, school meals patronization, experience of foodborne related diseases and food hygiene improvement recommendation for school kitchens.

School kitchen matron's questionnaire (Appendix 4) targeted demographics of matrons or managers, the availability or absence of Food Safety Management Systems and willingness of matrons or managers to adopt HACCP.

School kitchen staff also were presented with questionnaire (Appendix 3) on their demographics, food hygiene awareness, current food hygiene practices and a test which was scored before and after food hygiene training.

3.3.3. *Microbiological evaluation*

Quantitative evaluation of microbial load was conducted for Aerobic Colony Count (ACC), *B. cereus,* total coliforms, *Staphylococcus aureus,* yeast and moulds in jollof (cooked rice in vegetable and fish or meat sauce) and other cooked rice meals. In place of *B. cereus* the presence or absence of potential *Salmonella spp*. in groundnut soup (peanut butter soup with fish or meat and other added ingredients) was also analysed.

ACC, total coliforms, *Staphylococcus aureus,* yeast and mould, for staff hand hygiene and ACC, coliforms, yeast and mould for 4 food contact surface swabs from the 11 schools were conducted before and after Good Hygiene Training.

Similar analyses for 5 schools after HACCP training were also studied.

3.3.3.1 *School Meals*

A total of 76 food samples were collected for study. Duplicates of two high risk, Ready-to-Eat meals each from 11 schools were collected for microbiological quality and safety before Good Hygiene Training. One Ready-to-Eat meal was sampled from the 11 schools to investigate the effect of training intervention on food safety.

Microbiological quality of the Ready-to- Eat meal from 5 schools selected for HACCP implementation and training were also analysed and data was compared with previous data from before and after Good Hygiene training to measure the significant difference of the interventions on the levels of ACC, *B. cereus*, total coliforms, *S. aureus*, yeast and moulds and the presence or absence of potential pathogen *Salmonella spp*.

3.3.3.2 *Environmental sampling (food contact surfaces and staff hand swabs)*

A total of 216 food contact surfaces and 54 staff hands swabs were sampled. Four food contact surfaces including metal ladles, serving utensils, grinders, knives and staff hands were used for the study for ACC, coliforms, yeast and mould and for staff hands *Staphylococcus aureus.*

3.4 Sample Preparation and analysis

3.4.1 *Sample Preparation*

Food: For microbial analysis, 100g of food samples were collected in sterile stomacher bags (Plate 1) in duplicates.

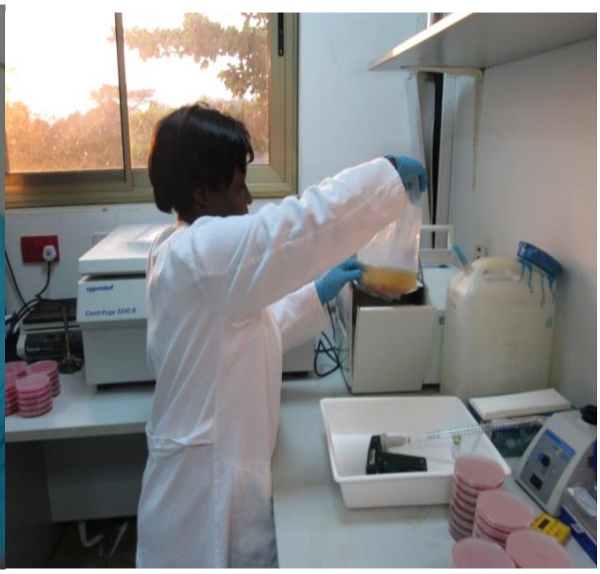



Plate1. Weighing of Jollof rice in stomacher bags. Plate 2. Jollof rice in BPW ready for homogenizing in stomacher

Samples were placed on ice till they were analysed. For enumeration and detection of ACC, *B. cereus*, total coliforms, *S. aureus*, yeast and moulds, 25g of food sample was weighed out into sterile stomacher bags and 225 ml of BPW was added to the weighed sample (Plate 2) and homogenised using a stomacher set at 200rpm for 2 minutes. Serial dilutions up to 10^6 were done in sterile BPW for each sample before plaiting onto appropriate agar/media. Depending on the organism, each culture medium was incubated for specified temperature and time.

Staff hands and food environment swabs:

Staff hands (palm, in-between fingers and back of palm) were swabbed after washing. Swab sticks were placed back in labelled BPW (10ml) containing tubes. Samples were transported on ice and analysis commenced within 4 hours of sampling.

A 5cm x 5cm ($25cm^2$) area of cleaned food contact surfaces (student's meal pans, kitchen knives and disc attrition mills/grinders for either vegetables or corn and food serving ladles) were swabbed. Swabs were aseptically transported on ice to laboratory until work commenced. Swabs with diluents were vortexed and 1ml were aseptically transferred into 9 ml of BPW making 10^2 dilution. Serial dilutions from 10^3 to 10^6 were made for each sample and 0.1ml portions were inoculated on respective agars and incubated for stipulated temperature and time.

3.4.1.1 *Enumeration*

Total colonies were counted, but those with 20 to 200 colonies for bacteria and 10-150 for yeast and moulds per plate (Sutton, 2011) were used. Samples that had no colonies formed (lowest level of detection) were estimated as having less than 2 $Log_{10}CFUg^{-1}$ or ml^{-1} for food and cm^{-2} for swabs, thus of the highest concentration in the serial dilution. Those with colonies exceeding the upper limit for all plates were estimated as having 200 $CFUg^{-1}$or ml^{-1} or cm^{-2} for the next possible lowest concentration of the serial dilution (American, Society of Testing Material, 1998). Mean Colony forming units were calculated for each sample and for food contact surfaces each value was divided by area sampled (25 cm^2) to get the CFU cm-^{2}, for staff hands values were divided by $100cm^2$ (approximated area per hand). Log values for CFU cm^{-2} for utensils and staff hands and $CFUg^{-1}$ or ml^{-1} for jollof rice and groundnut soup respectively were then calculated and used in data analysis.

3.4.2. *Aerobic Colony Count for Food, Hand swabs and Food contact surfaces (ISO 4833: 2003) Sospedra et al (2013)*

A portion (0.1 ml) of serial dilutions were inoculated and spread on duplicate plates of standard PCA and incubated for 72 +/-3 hours at 30 ℃ +/-1. After incubation plates with colonies between 20– 200 were selected and counted. Colony forming units ($CFUg^{-1}$ or ml^{-1} or cm^{-2}) of samples were calculated.

3.4.3. *Total Coliforms in food samples, hands and food contact surfaces swabs.*

Homogenised samples were serially plated on prepared selective media MacConkey agar and incubated for 48 hours at 37℃. After incubation plates with between 20-200 colonies which were gram negative lactose fermenting and non-lactose fermenting bacteria were counted. Mean values were used to calculate the colony forming units per sample.

3.4.4. *Enumeration of Yeast and mould on food, hands and contact surfaces*

Portions (0.1ml) of serial dilutions of food and food contact surfaces were inoculated and spread plated on Dicloran rose-bengal chloramphenicol (DRBC) agar **(**Bacteriological Analytical Manual 2001**).** Plated samples were incubated at 25℃ for 5 days in a dark environment and colonies of yeast and moulds were counted for plates with 10-150 colonies and CFU g^{-1} for jollof rice, CFU ml^{-1} for groundnut soup, and $CFUcm^{-2}$ for food contact surfaces and staff hands were calculated.

3.4.5 *Presence or absence of Salmonella spp in soup samples. ISO 6579 (ISO, 2002)*

Pre enrichment: 25 ml of food sample was homogenised with 225ml of Buffered peptone water. (BPW). Sample suspension was then incubated for 16-20 hours at 37℃.

Selective enrichment: A portion (0.1 ml) of culture was transferred to 10ml of Rappaport-Vassiliadis broth with soya (RVS) (Van der Zee, 2003, Sospedra *et al*, *2013*). RVS broth were incubated for 24 hours at 37℃.

Selective plating: Loopful (3mm) of culture from RVS were streaked on Xylose-lysine-deoxycholate (XLD) agar and Bismuth sulphite agar and incubated at 37 ℃ for 24 hours. Typical colonies were identified.

Purification: Three (3) loopful of presumptive colonies of *Salmonella* were sub cultured on Nutrient agar by streaking and incubated at 35 ℃ for 24 hours for purification.

Biochemical test: Sterile inoculating needle were used to inoculate Triple sugar iron (TSI) agar and Lysine iron (LI) agar slants with single colonies of presumptive *Salmonella* and incubated at 37 ℃ for 24 hours +/- 2 hours. Gas production and H_2S gas and pH changes were observed. Gram staining, oxidase test, indole test and API 20E were conducted for confirmatory test.

3.4.6 *Enumeration and Isolation of Staphylococcus aureus in food and staff hand swabs*

A portion (0.1 ml) of the inoculated BPW was spread plated on Baird-Parker agar with egg yolk tellurite emulsion and incubated at 37 ℃ for 48 hours (Santana, *et al*, 2009, Sospedra *et al*, 2013). Typical colonies (black, convex and with or without halo on BP agar) were counted and $CFUg^{-1}$ calculated using plates with 20 to 200 colonies.

Biochemical test: Typical colonies of presumptive *S. aureus* were aseptically inoculated onto 0.2 - 0.3 ml of 5 Brain Heart infusion (BHI) broth tubes and thoroughly emulsified. BHI suspension were then incubated at 35 ℃ for 18-24 hours. Reconstituted coagulase plasma (0.5ml) was then added to BHI culture and incubated at 35℃. Coagulation was observed from 1 hour of incubation to 6 hours.

Gram staining, microscopy, catalase test and API Staph. test confirmed organism.

3.4.7 *Enumeration and identification of Bacillus cereus in food samples.*

A portion (0.1ml) of BPW homogenate serially diluted was inoculated by spread method on a selective media Brilliance *Bacillus Cereus* agar with added egg yolk emulsion and polymyxin B. Plates were incubated for 24 hours at 37 ℃ (Edema *et al,* 2008, Blackburn and McClure, 2009). Typical blue colonies with halo zone of egg yolk precipitation were counted on plates with 20 – 200 cells and $CFUg^{-1}$ calculated for jollof rice.

Gram staining, microscopy with further oxidase and motility test were used as confirmatory test.

3.5. Adoption of Good Hygiene Practices

Training was conducted for all kitchen staff (matrons, cooks and pantry men/servers). Training took a maximum of three (3) hours. Two (2) hours for presentation and videos and questions and answers and break. Thirty (30) minutes for demonstrations and thirty (30) minutes for assessment.

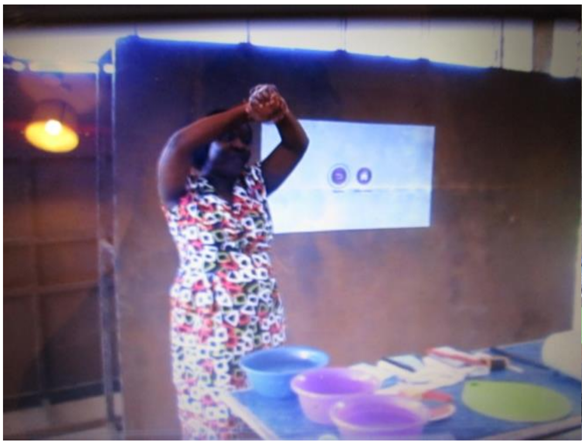


Plate 3. Researcher demonstrating hand washing procedure **Plate 4. Kitchen staff using soap on hands**

Plate5. Researcher uses Pro-clean to demonstrate colour change (violet) without soap **Plate 6. Comparing Hygiena-Proclean after effective washing with soap (green colour)**

The presentations were on;

i. Summary from previous audit and implications on food safety (Appendix 6)

ii. Power point presentation on importance of Good Hygiene Practices including the 1992 Food and Drugs Law in Ghana and the requirements for food handlers Sections 1 to 6 and 7 were used (Appendix 6).

iii. An FSA presentation on the Safer Food Better Business for catering staff (Version 3 2009 FSA/0662/0712) was used for training of kitchen staff on the four C's, cooking, chilling, cleaning and cross contamination prevention (Appendix 9).

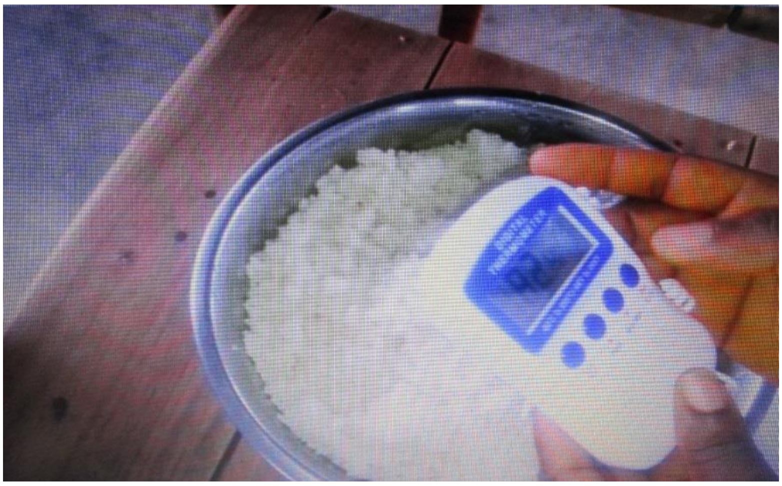


Plate 7. Kitchen staff practicing food temperature monitoring with food probe provided by researcher.

Demonstrations;

i. Good hand washing procedure (clean water, soap and clean towel for drying) was demonstrated and staff randomly chosen to repeat procedure. Pro-clean, a protein residue test kit from Hygiena UK was used to demonstrate cleaning effectives using the appropriate cleaning procedure (Plates 3- 6).

This kit worked on colour change by detecting protein from green (pass), grey (caution) and violet (fail), within 1 to 10 minutes of releasing its reagent on a surface test swab (www.hygiena.com). The more protein contamination (80µg:50µg:20µg) the quicker the colour changes (1min: 5min: 10min) and darker it became.

ii. Effective food contact surfaces cleaning steps were also conducted. Rinse, wash, sanitize and rinse using approved detergents and warm water or sanitizer.

iii. Temperature and time monitoring for cooking and service were done by probing the food at the last stage of preparation towards service with cooking and service time to official dining time (food holding time) monitored (Plate 7).

Staff hygiene knowledge and hygiene practices before and after training were assessed using a questionnaire developed based on Codex Alimentarius Commission guidelines for mass catering (CAC, 1993) and Fundamentals of Food Hygiene questions from The Royal Society of Public Health UK (2007) with some modifications.

3.6 Adoption of HACCP

Five (5) schools were selected based on school's management approval, staff preparedness and the availability of basic needs including designated food storage area, preparation area and service area. Prerequisite measures available were studied and documented. Non-available ones were introduced and matrons trained on them during 2 matron's workshops which took a maximum of 3 hours each (Plate 8). A document on GHP, HACCP Plan for jollof rice and related records were developed for schools (Plate 9-10) (Refer to Appendices 5, 7 and 8). Staff practices and food safety levels after HACCP implementation were analysed.

Plate 8. Matrons practicing flow diagram design during HACCP training workshop

3.7 Incentives

Water holding containers and sponge holders (Plate 11 and 12) were provided for two poor hygiene schools and one medium hygiene category school who needed these facilities to promote good practices. Two temperature probes one for cooked food and the other for refrigerator temperature monitoring were provided for all 5 schools, Good Hygiene Practices manual for SHS kitchens developed by the researcher (Plate 9 and Appendix 6) were also given to the 5 selected schools for HACCP studies.

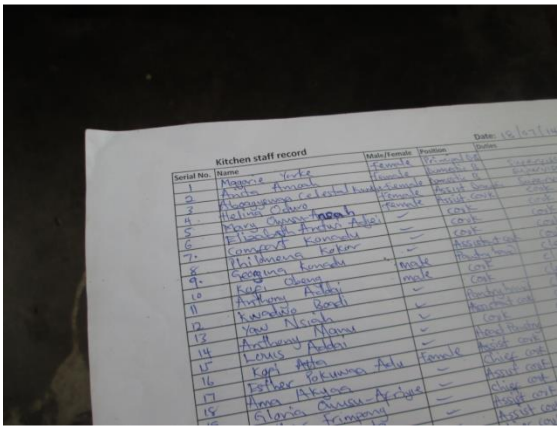


Plate 9. A matron with her GHP manual **Plate 10. Completed staff list record**

Plate 11. Water containers for school OO5. and O20 **Plate 12. Sponge storage containers for schools OO1 and OO4**

Matrons and staff in charge of probes were given induction on usage and internal probe calibration. Some staff were also given tokens in cash and kind when asked of the researcher towards creating a friendly environment for studies.

3.8 Statistical tools and Data Analysis.

Qualitative analysis of food safety management systems availability in both Lincolnshire and Ashanti Region, their maintenance and preparedness of school matrons to welcome HACCP in schools were analysed using frequency distributions and cross tabulations of the SPSS version 21 software and compared.

Kitchen staff hygiene awareness and practices were analysed using cross tabulation to find the effect of country or location and school hygiene category on staff practices and performance.

Student's food hygiene awareness and experience of food borne diseases in schools were analysed qualitatively and the economic and academic impact of foodborne diseases and hazards in food were studied.

The effectiveness of the two interventions were evaluated by assessing the changes in personnel good hygiene practices knowledge scores and personal hygiene practices scores. The changes in cooked food temperature at time of service and the holdint time between service and meals time were also assessed. Microbiological evaluations in terms of log reductions in ACC, *Bacillus cereus*, total coliforms, *Staphylococcus aureus,* yeast and mould, and presence or absence of *Salmonella* were also measured.

The effect of GHP training and HACCP intervention on hygiene awareness and practices of kitchen staff and effect on food safety were analysed with the use of T- test equivalent for non-parametric data (Wilcoxon's Signed Rank Test and Friedman's Test) using SPSS and Bar charts on Microsoft Excel after testing for normality of data with Shapiro-Wilk Test. Graphical presentations on pre and post intervention scores and data were developed using General linear Model for Repeated Measures on SPSS and Bar charts from Microsoft Excel 2013.

Post hoc test was conducted using Wilcoxon's signed- rank test with Bonferroni's adjustment to examine which intervention created a significant improvement from Pre intervention data.

CHAPTER 4

4.0 RESULTS AND DISCUSSION

This chapter addresses the results and outcomes of the research. Data from Pre GHP, Post GHP and Post HACCP were analysed and discussed with special attention to students report on incidence of FBD's, the effect of staff hygiene practices on food safety, effect of GHP and HACCP intervention on food safety and hygiene practices of kitchen staff in the Ashanti Region of Ghana.

4.1 Survey of foodborne diseases in Senior Secondary Schools in the Ashanti Region of Ghana.

The possible incidence of foodborne disease in Senior Secondary Schools in the Ashanti Region was investigated with the help of questionnaire for boarding SHS students in Ashanti Region of Ghana. One hundred and eighty (180) boarding students who used the dining hall were randomly sampled from 45 schools (4 students per school) for the survey.

4.1.1. *Demographics of students used in the research*

Out of the 180 SHS students sampled from 45 schools, 48.9% were males whilst 51.1% were females. Students in their second year were 54% whilst those in first year were 46% (Table 4). Almost all the students had food poisoning awareness (some knowledge of causes and symptoms) with the exception of 7 (3.9%) who had no awareness and one who was not certain about what food poisoning was. Approximately half (50.5%) of the sampled students attended dining hall for meals all the time whilst the rest attended most of the time or some of the time. Almost all students had other sources of meals that supplemented their regular dining hall meals. Only 3.9 % depended wholly on school meals. Food was not strictly from the school catering facilities even though schools provided three square meals for students (Afoakwa, 2005). Other sources of meals included students own stored food in chop boxes, food from vendors who sell on school premises and food brought to students from home during visiting hours. This could make holistic food safety control by kitchen matrons or managers much more difficult in the schools.

Table 4. Demographics of 180 SHS students from Ashanti Region

	Frequency	Percentages
Gender		
Male	88	48.9
Female	92	51.1
Academic level		
First years	83	46.1
Second years	97	53.9
Food poisoning Awareness		
Yes	172	95.5
No	7	3.9
Not sure	1	0.6
Attendance to dining hall for meals		
All the time	91	50.5
Mostly	48	26.7
Sometimes	41	22.8
Other sources of meals for students		
My own stored food	74	41.1
Food vendors in school	10	5.6
Home meals	19	10.6
Food vendors and home meals	1	0.6
Food vendors and shops	1	0.6
My own stored food and home meals	1	0.6
None	7	3.9

4.1.2. *Foodborne illness awareness and experience in schools*

From Table 5, students in both levels were aware of foodborne disease and there was no significant difference between the two academic levels on awareness. Knowledge on food borne diseases was gained from the media, books, parents, academic programmes and personal experience. Those who had ever experienced foodborne illness in school were more than half of the population sampled although a higher percentage did self-confirmation of the possible cause of their illness. Approximately fifty two percent (51.7%) of the students sampled had some form of foodborne illness during school term, 21.1 % (1:5 of students) reported to have their foodborne illness confirmed by recognised health officials whilst 30.6 % only blamed food they had eaten to be the cause of their illness.

Table 5. Foodborne disease (FBD) awareness, occurrence among academic levels and sources of confirmation of related experience among 180 SHS students in percentages

	FBD awareness					
Academic levels	Yes	No	Not sure	No response	Total	Chi square
First year	44.4	1.1	0.6	0.0	46.1	2.118(0.714)
Second year	51.1	2.8	0.0	0.0	53.9	
	Rate of FBD occurrence per school term					
Academic levels	Once	Twice	Three to Four times	Can't remember + NA	Total	Chi square
First year	9.4	7.2	5.0	24.5	46.1	9.177(0.515)
Second year	12.2	9.4	3.9	28.4	53.9	
	Source of confirmation of related foodborne illness experienced during school term					
Foodborne illness experienced in School	School Nurse	A Doctor	Personal decision	Not Applicable	Total	Chi square
Yes	4.4	16.7	30.6	0	51.7	101.560(0.001)
No	2.8	6.1	7.8	31.7	48.4	

NA- Not applicable

This was higher than the FAO/MoFA (2007) report of 1 in every 40 Ghanaians experiencing FBD annually. Those who had fallen sick during school term due to foodborne illness were significantly higher than those who had not. Frequency of FBD occurrence was high as 25.5 % of the students reported to experience it between 2 to 4 times per school term and 21.6% had it once. Reporting was however low as less than half of the affected students visited the hospital or sought medical attention for their ailment thus supporting Tomlins *et al* (2002) on low reporting culture of FBD in Ghana. This supports Afwoakwa (2005) and Bankole *et al* (2012) who also reported that students in boarding schools were subjected to unhygienic food due to poor sanitary conditions in Ghana and Benin respectively. Lack or low level of publicity of foodborne infections cases from schools might create the illusion that existing practices were acceptable leading to lack of motivation on the part of matrons to adopt standard working practices.

4.1.3. *Available food hazards in school meals and food allergy management*

Most students (66.4%) were concerned about high levels of physical contaminants in school meals, 35.2% reported chemical contaminants, 20.9% reported combination of contaminants in meals and 6.9% reported mould (Fig. 5).

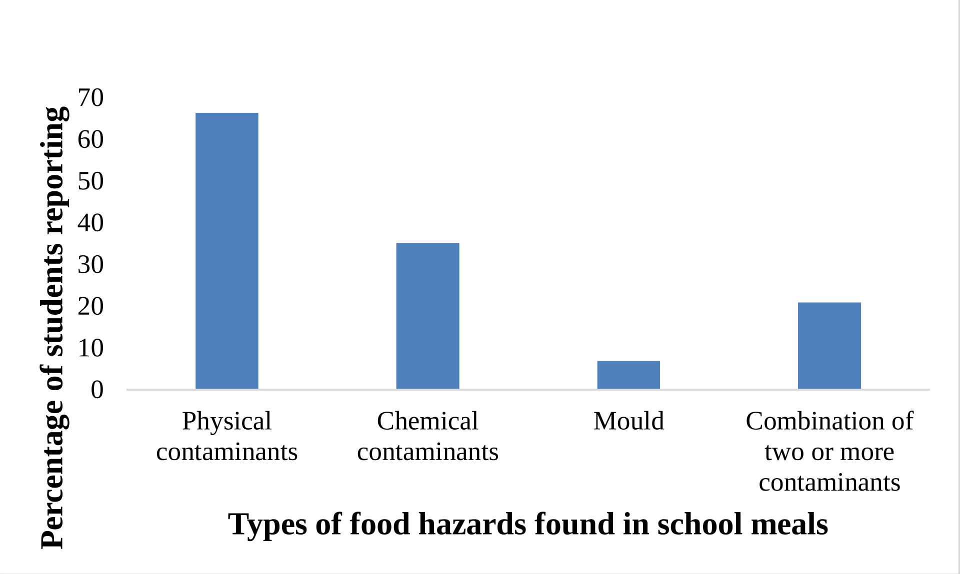


Figure 5. Percentage of students reporting food hazards experienced during school meals

This follows the already acknowledged pattern of recognising hazards in food. Physical contaminants are much more easy to find and can be removed from food or food could be declined, chemical contaminants are recognised mostly due to change in the smell or taste of the food. Microbiological contaminants on the other hand are not easily recognised with the exception of physical growth of mould on food and other related spoilage issues (Wallace, 2009). Pathogens could be present but are microscopic and presence can only be confirmed in the laboratory. Among the physical contaminants present in school meals in Senior Secondary Schools in Ashanti Region, stones were the highest food hazard followed by insects, human hair and metallic substances (Figure 6). This happens when there is absence of Good Hygiene Practices including Supplier control, Raw material specification and Processing control, Integrated pest management and Personal hygiene.

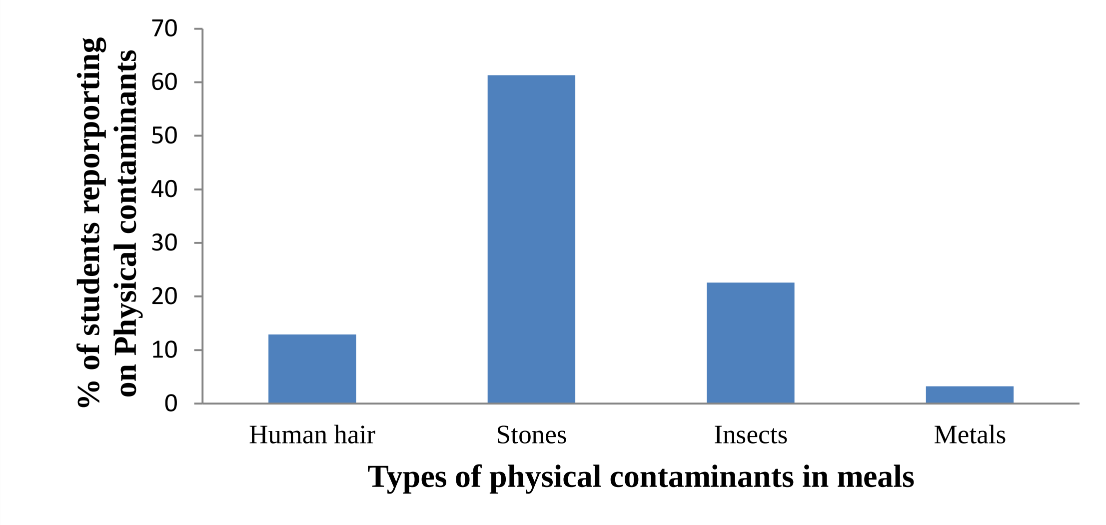


Figure 6. Percentage of students reporting types of physical contaminants in meals

Ababio and Adi (2012) and Afoakwa (2005) reported of the absence of GHP's among food handlers in Kumasi Metropolis and poor sanitary conditions in schools in Ghana respectively. Food allergy and intolerance among consumers is increasing (Sprenger, 2009) and Figure 7 shows food and ingredients that Ghanaian students surveyed had some form of allergy or intolerance with. These included peanuts, eggs and milk, seafood, gluten, monosodium glutamate and okro. The 'other' response included beans or cowpea. The rising cause of food allergy and its effects in Ghana is not known (Obeng *et al* 2011 and Boye, 2012) but there is a need for control as some reactions could be fatal and the report from students show the existence among consumers. This report adds additional sources of food allergy and intolerance in adolescents to the peanut and pineapple report in children of 5-16 years old in Ghana by Obeng *et al* (2011). From Table 6, over half of the students sampled (56%) had a form of allergy or intolerance and were more likely not to report when in school but would avoid such meals when prepared or served. Of the 56% who had food allergy or intolerance, only 37% of these (20.5% of total) had reported food allergy and only 24% were given a special diet that is 13% were not given any consideration from school kitchens.

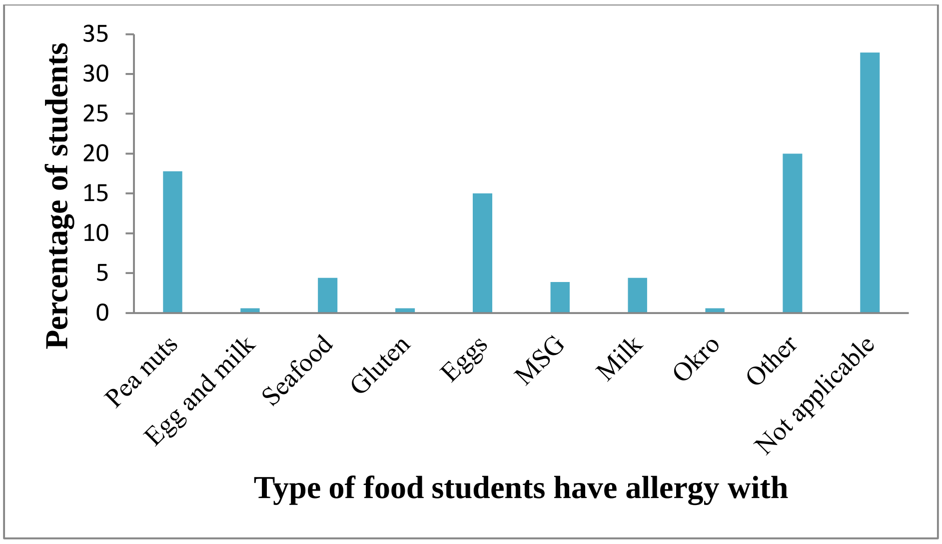


Fig. 7. Food that students have allergy /intolerance problems with

There was a significant difference between food allergy or intolerance level and forms of allergy or food intolerance management in the schools. Students with food allergies and intolerance would normally present a medical report to matrons for alternative meals. Those without medical report may be considered not to have genuine cases which could lead to students being ignored or not being given alternative meals. Such students might be considered not have any health related issue for a particular food but only a dislike for it. Afoakwa reported of absence of fruits on students menu in SHS in the Ashanti Region of Ghana. In Korean schools, Ryu *et al* (2011) reported of the provision of a variety of side dishes and desserts with the main meal in schools. This was not present in the schools in Ashanti Region. Thus these may be additional factors that encouraged the use of other sources for food including food vendors in the schools. This did not significantly affect the level of attendance to dining hall among students although food allergy and intolerance could be contributing factors to infrequent dining hall attendance which constituted 25.4 % of students sampled. Also 25% of those who had food allergy reported to absent themselves and not go to the dining hall sometimes whilst only 13% of those who did not have food related allergy reported likewise. The group which did not know if they had a problem or not but refused to take school meals or attend to the dining hall all the time could also be educated to make informed decisions as 33%

of them avoided some meals probably due to their dislike for a particular food, absence of variety including fruits (Afoakwa, 2005) or due to the availability of other food sources.

Table 6. Food Allergy management and effect on dining hall attendance (in percentage of students surveyed)

	Allergy management					
Food allergy	I have not reported but avoid those meals	Reported and I am given special diet	Reported but not given special diet	Not applicable	Total	Chi square
Yes	35.5	13.3	7.2	0.0	56.0	129.405(0.001)
No	0.0	0.0	0.0	29.0	29.0	
Don't Know	0.0	0.0	0.0	15.0	15.0	

	Attendance to Dining Hall for meals					
Food Allergy	All the time	Most of the time	Sometime	Never	Total	
Yes	30.5	11.6	13.9	0.0	56.0	9.333(0.053)
No	15.6	9.4	4.0	0.0	29.0	
Don't know	4.4	5.6	5.0	0.0	15.0	

Reported in percentage of students

4.1.4. *Economic and Academic impact of food borne illnesses in Senior Secondary Schools*

The benefits of providing meals to school going children by administrators are to ensure that students have good health, and development and also to encourage continued education (Santana *et al*, 2009, WHO, 2002, Oranusi *et al*, 2007). Foodborne illness and related problems cause economic loss to countries world over and Ghana is not an exception (MoFA/World Bank, 2007). From Table 7, 49.4% of students sampled who experienced some form of foodborne illness spent at least a day to more than 5 days from school or active academic work. Thus supporting Odame-Darkwa, (2008) who reported that FBDs in Ghana cost the government 594,279 productive days in 2006. The seriousness of the disease if considered to determine how long a student recovers from illness did not however have any significant effect on the level of attendance to the dining hall for meals. This could be due to possible school rule on compulsory attendance to the dining hall by students whether they would eat or not.

Table 7. Level of attendance to Dining Hall and days and amount spent by students who suffered from foodborne illness during school term reported in percentages

	Length of days spent off school								Chi square
Attendance to dining hall	1 day	2 days	3 days	4 days	5 days	More than 5 days	Not Applicable	Total	
All the Time	4.0	2.8	10.0	1.1	5.5	2.8	24.4	50.7	20.859(0.105)
Most of the time	0.5	4.4	2.8	1.1	0.5	0.0	17.2	26.5	
Sometime	1.7	3.3	5.0	0.5	1.1	2.2	9.0	22.8	
	Amount Spent on Medication								
Attendance to dining hall	1.0 - 10.0 GhC	11.0 - 20.0 GhC	21.0 - 30.0 GhC	31.0 - 40.0 GhC	More than 50.0 GhC	Can't Remember	Not Applicable	Total	Chi square
All the Time	14.0	8.3	4.4	0.5	4.0	2.8	16.7	50.7	26.107(0.010)
Most of the time	7.2	2.7	2.7	0.0	0.0	1.1	12.8	26.5	
Sometime	2.2	5.5	4.0	1.7	3.3	1.1	5.0	22.8	

Students possibly use over the counter medication as a lesser percentage reported their sickness to health facilities (Table 5) than those who spent money on medication

Sickness goes with spending as the sufferer would need medication, other health related investigation if available and attendance depending on the level of discomfort. Out of the 180 students sampled, 60.5% spent some amount of money ranging from 1.0 to 50.0 Ghana Cedies (GhC) (up to £ 7.15 or $ 11.36 in 2015 currrency rate) on medication due to foodborne illness during school term. This equally supports the 1 in every 40 Ghanaian suffering from serious foodborne illness annually (MOFA/World Bank, 2007) and costing the government $ 69.00 million (GhC 303,697,183.00). There was a significant difference (p= 0.01) between the level of attendance to dining hall for meals and the amount of money spent by students. Those who attended the dining hall sometimes were more likely to spend more money on medication than those who went all the time or most of the time. Whilst 5% out of the 22.8% of those who attended dining hall sometimes paid higher cost for medication (GHC 30.0 - ≥ 50.0), only 4.5% of the 50.7% who attended all the time paid this higher range of money on medication (Table 7). Cost was borne either by National Health Insurance Scheme (15.6%), parents (30.6%), the school (8.3%) or student (7.2%) and other combinations of the above (2.3%). Again although only 21.1% (Table 5) of students had reported to have visited hospital during foodborne infection experience, 60.5% (Table 7) reported to have spent money on medication on related issues. An indication of low reporting culture and possible self-medication with over the counter drugs among students in SHS in Ashanti Region of Ghana.

4.1.5. *Recommended hygiene improvements suggested by students*

All the students responded in the affirmative on the need to improve food hygiene and kitchen hygiene practices in their schools. The listed GHP were potable water, hand washing facilities, an enclosed kitchen, pest control, hot food, clean utensils and protective clothing for kitchen staff.

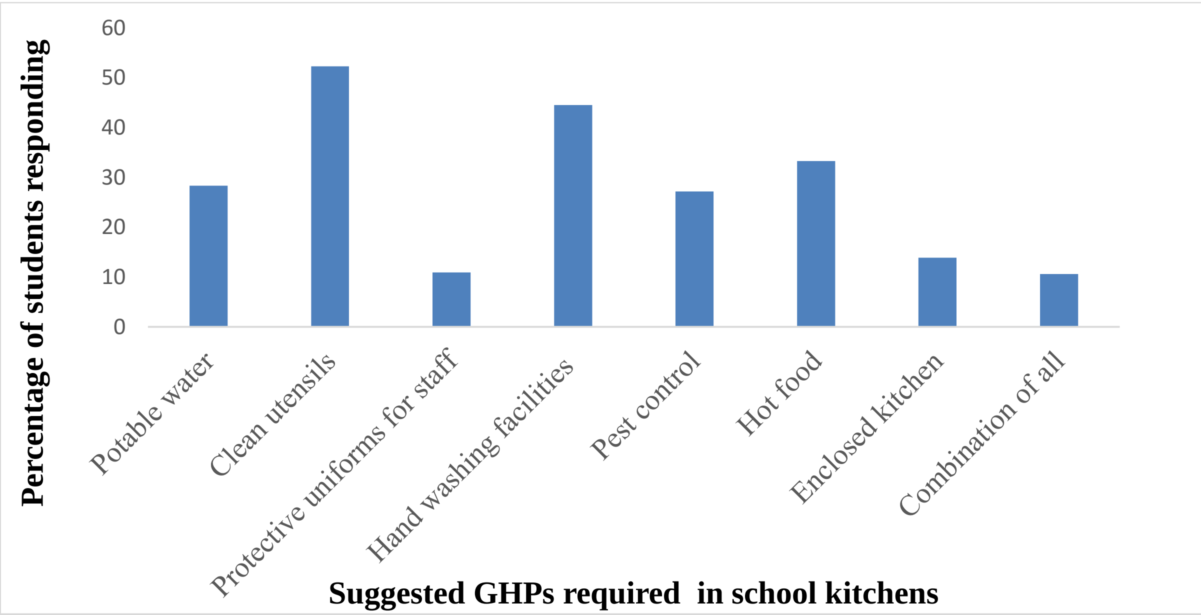


Fig. 8. SHS boarding students recommended improvements in GHP in school kitchens

From Figure 8, clean utensils was the single most mentioned recommendation by 52.5% of the students. This was followed by the need for hand washing facilities in both the kitchens and dining halls (44.5%). Hot food was the next recommended food hygiene practice by 33.3% of the students followed by potable drinking water (28.3%). Pest control was next with 27.2% recommendations then enclosed kitchen (13.9%) before protective uniforms for staff (10.9) and a combination of all the listed GHP's (10.6%). Thus most of the schools needed improvement even as suggested by the students. This goes to support the need for improved food safety management systems in our Senior Secondary Schools as recommended by Afoakwa, (2005) and Bankole *et al*, (2012) in order to provide safe food for students.

4.1.6 *Summary*

Approximately 52% of the 180 first and second year students sampled in SHSs in Ashanti Region had experienced FBD during school term with rate of occurrence ranging from one to four times per term although only 21.1% had their cases confirmed by recognised health officials. Thus the culture of reporting FBD incidence was low among SHS students and students were more like to self-medicate than visit the hospital. Students had information on food poisoning and related symptom. Physical contaminants in food were the predominant food hazard found in school meals of which stones was the highest reported followed by insects, human hair and metals. Although less is known about food allergy in the country, 56% of the students had some form of food allergy or intolerance but only 37% of these (20.5% of total) had reported and only 24% were given alternative meals by matrons. This however did not seem to affect the level of attendance to dining halls although students were more likely to avoid such meals when served. FBDs experienced did not deter students from patronizing school meals and those who did attend sometimes and substituted with other sources of meals significantly paid higher money on medication than those who went all the time. Thus other sources of available food for students could also present foodborne infections. The incidence of food poisoning and foodborne diseases although not reported seemed to be higher than the 1 in every 40 Ghanaian case reported by FAO/MoFA (2007) as 1 in every 5 of the sampled students reported to have had an officially confirmed case of FBD during school term within their 1 and 2 years in school. This required an intervention in the forms of Good Hygiene Practices as suggested by the students and other food safety measures like HACCP to help improve on current practices in the schools. Regular monitoring and surveillance by the appropriate stage agencies were equally needed.

4.2. Food hygiene awareness and practices among kitchen staff in Senior Secondary Schools in Ashanti Region of Ghana and Lincolnshire-United Kingdom.

Staff hygiene practices and awareness directly or indirectly affect the safety of their consumers. The presence or absence of Good Hygiene Practices including kitchen design, supplier control and process flow in the kitchen also affect the safety of food. These standards were studied among ten (10) secondary school kitchens in the Lincolnshire, UK and forty five (45) school kitchens in Ashanti Region of Ghana with the use of an adopted auditing list by Santana *et al* (2009). Ten (10) matrons in UK and forty five (45) matrons in Ghana, twelve (12) UK kitchen staff and one hundred and eighty (180) kitchen staff in Ashanti Region of Ghana were also surveyed for availability of food safety management systems and food hygiene awareness and practices respectively with the use of self-designed and administered questionnaires.

4.2.1. *Schools demographics*

Most schools in both regions were old and above 40 years although the number of schools that were very young in the Ashanti Region were higher as compared with Lincolnshire. Kitchen staff strength (total number of staff) in Lincolnshire was significantly lower than the numbers present in the Ashanti Region of Ghana. Approximately 51% of the schools had number of staff from 20 to 40 and 11.1% had over 40 staff in the Ashanti Region. The number of staff between the two countries was significantly different. Seventy percent (70%) of the schools in Lincoln used 1-10 staff in their kitchens. This could be due to the type of meals prepared, the availability of automated systems for cooking and numbers of students fed. Schools in Lincolnshire fed up to 1000 students (Table 8), whilst the students who patronised school meals in the Ashanti Region were higher. Approximately 60% of schools in the Ashanti Region had a boarding student population between 1000 and 3000 (Table 8).

Table 8. Kitchen staff numbers, age of schools and students fed by schools in Lincoln- UK and Ashanti Region of Ghana in percentages

			Age of school buildings				
Region	1-10 years	11-20 years	21-30 years	31-40 years	> 40 years	Total	Chi square
Lincoln- UK	1.8	3.6	1.8	0.0	11.0	18.2	191.383(0.001)
Ash. Region Ghana	9.1	3.6	25.5	3.6	40.0	81.8	
			Number of staff				
Region	1-10	11-20	21-30	31-40	> 40	Total	Chi square
Lincoln- UK	12.7	5.4	0.0	0.0	0.0	18.2	26.217(0.001)
Ash. Region Ghana	5.4	14.5	23.5	27.3	11.1	81.8	
			Students population fed by school kitchens				
Region	1-500	501-1000	1001-2000	2001-3000	>3000	Total	Chi square
Lincoln UK	9.1	9.1	0.0	0.0	0.0	18.2	11.909(0.008)
Ash. Region Ghana	14.5	18.1	31.0	18.2	0.0	81.8	

Data reported in percentage of total staff. 180 from Ghana and 12 from UK

Thus the student population being fed by schools was significantly different between the two countries and number of kitchen staff positively correlated (Spearman's correlation r = 0.846 $p < 0.05$) with the number of students being fed in Ghana. Thus the higher the number of students being fed the higher was the staff strength (number of staff). Kitchen staff activities included food preparation practices like, sorting, winnowing, washing, picking, roasting, cooking, moulding (rice balls, kenkey and banku), serving, and cleaning manually in the Ashanti Region whilst most of these activities were absent or automated in Lincolnshire. Food types were also different with those in Ghana demanding more time and also labour intensive.

4.2.2. ***Secondary Schools kitchen audit scores on hygiene standards in both Lincolnshire-UK and Ashanti Region of Ghana***.

Food Safety Management practices in both countries were significantly different for all the listed GHP parameters. Facility design and layout scores for the Lincoln schools were excellent (90-100%), schools were devoid of unsanitary conditions, independent and free of old objects, pest and animals. Suitable and clean floors, ceiling, walls, doors and windows with proper ventilation and available suitable toilet facilities and staff changing rooms. Of the 45 schools from Ashanti Region, 48.8% had poor facility design, whilst 42.2% were medium. Most schools kitchens in Ashanti Region were not properly walled or with ceiling on roof, those enclosed lacked standardised cleaning and maintenance procedures. Some schools, due to locality were disturbed by the intrusion of animals and pests. Eighty percent (80.0%) of the sampled schools in the Ashanti Region did not have suitable toilet facilities (availability, proximity, properly maintained) with hand washing basins and hand hygiene products for staff (Afoakwa, 2005). Staff used a centrally placed multipurpose tap in the kitchens for hand washing without suitable hand antiseptics. Changing rooms were either not available or poorly managed requiring supervision. Sixty seven percent (67.3%) of the schools had access to clean potable water, whilst 32.7% used bore holes, external tanker supplied water stored in polystyrene tanks and other concrete reservoirs in Ashanti Region. Schools in Ashanti Region mostly had school own dug area for dumping refuse. Bins with suitable lids to prevent pest ingress were present in only a few. Utensils and equipment maintenance in all 10 Lincoln schools were standardised as 90.0% of the schools had a planned maintenance culture. All Lincolnshire schools had suitable tables and work tops for both kitchen and dining halls.

Table. 9. Food safety management evaluation in Secondary schools in Ashanti Region and Lincoln (reported in percentages)

Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Facility design scores							
Lincoln-UK	0.0	0.0	0.0	0.0	18.2	18.2	48.889(0.001)
Ashanti R/.Ghana	0.0	40.0	34.5	5.5	1.8	81.8	
Utensils and equipment maintenance scores							
Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Lincoln-UK	0	0	0	0	18.2	18.2	48.889(0.001)
Ashanti. R/Ghana	9.1	38.2	23.6	9.1	1.8	81.8	
Employee personal hygiene practices scores							
Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Lincoln-UK	0.0	0.0	0.0	0.0	18.2	18.2	55.000(0.001)
Ashanti. R/Ghana	0.0	1.8	16.4	18.2	45.4	81.8	
Quality of raw and ready to eat food scores							
Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Lincoln-UK	0.0	0.0	0.0	0.0	18.2	18.2	55.000(0.001)
Ashanti. R/Ghana	0.0	5.4	76.4	0.0	0.0	81.8	
Flow of product/handler/service scores							
Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Lincoln-UK	0.0	0.0	0.0	0.0	18.2	18.2	48.889(0.001)
Ashanti R/Ghana	0.0	12.7	34.5	32.7	1.8	81.8	
Over all Food Safety Management practice score							
Region	0-19.9%	20-49.9%	50-69.9%	70-89.9%	90-100.0%	Total	Chi square
Lincoln-UK	0.0	0.0	0.0	0.0	18.2	18.2	55.000(0.001)
Ashanti R/Ghana	0.0	5.5	61.8	14.5	0	81.8	

(0.0-19.9)% - Very poor, (20.0-49.9) % - Poor, (50.0-69.9) % - Medium, (70.0-89.9) % - Good, (90.0-100) % - Excellent

There were freezers, fridges and hot holding equipment for suitable storage of food with thermometers which were in working condition. Suitable cleaning procedure including rinsing, washing with hot water, rising and disinfection with either chemicals or automated cleaning with hot water were available. Utensils after cleaning were also stored in safer area free of dirt and pest ingress.

Out of the 45 schools sampled from the Ashanti Region 57.8% scored between very poor and poor for utensils and equipment maintenance (Table 9). The main issues were absence of maintenance culture, absence of equipment for temperature control and monitoring, and mostly lack of a properly managed space for the storage of utensils. Giampoli *et al* (2002) and FSA, (2006) mentioned poor temperature and time control of food to be one of the most randomly abused practices among food handlers. Almost all the schools in Ashanti Region did not have sanitizing regime for cleaning of utensils and food contact surfaces. Cleaning procedure also lacked standardisation. These poor practices could be the cause of foodborne illness in schools sampled as reported by students from Table 4 and supports Marzona and Balzaratti, (2013) and Nicholas *et al* (2002) from Italy and United States respectively.

Personal hygiene practice among employees in both countries was significantly different among the kitchen staff. All staff from Lincoln had excellent scores (90.0-100%) for personal hygiene practice, whilst only 55.5% of staff from the Ashanti Region fell into excellent category. Twenty percent (20%) were medium in their personal hygiene practices and 2.2% were poor and the rest were good. The use of kitchen uniforms and aprons were prominent in most schools. Some staff (21.9%) in Ashanti Region still used unapproved jewellery including dangling ear rings, rubber bands on their hands, rings and uncovered hair whilst preparing food with matrons and supervisors being the main culprits. The Codex Alimentarius Basic Hygiene Text (2009) prohibits the self-adornment in food preparation areas where they could be a source of hazard. Even though the knowledge of hair covering existed, some staff refused to use any covering with complaints including 'too much hot environment' due to firewood and smoke in local kitchens. Since staff washed their own kitchen uniforms, daily washing was not practiced among all staff. Males in the kitchens in Ashanti Region predominantly did not involve themselves with protective uniforms and other good related practices even though their activities included helping ladies in the kitchen with heavy duties during food preparation, washing of utensils and carrying served meals to the dining halls. Staff in both countries washed hands after toilet, but some schools in the Ashanti Region had no readily available soap for staff to use after using the toilet hence staff used the same soap and standing pipe in their kitchens for hand washing. This unavailability encouraged poor hand washing practice as some staff reported not to wash their hands after visiting the toilet (4.2%) and before food preparation (12.5%). This poor hygiene practice is a management responsibility and could be corrected through the provision of suitable facilities and enforcement through supervision by deputies and training by kitchen matrons. Periodic health checks were done in both countries although health screening before employment was not evident in Lincoln.

There was a significant difference between the Lincoln schools and schools in Ashanti Region of Ghana on the quality of raw and ready to eat food. All the Ashanti Region schools scored between poor and medium category, whilst schools in Lincoln scores were excellent. Two factors considered included origin of raw food products. Although there were controls in both countries on procurement, matrons still depended on open market for perishable raw materials in the Ashanti Region. This affected traceability of food in the kitchen. Raw material specification was absent and products supplied in Ashanti Region including beans, pea nuts and maize had physical contamination issues that affected the meals prepared as seen from Figures 5 and 6. Whilst time and temperature control of food was available with suitable cold and hot temperature equipment for control and monitoring in Lincoln schools, kitchens in the Ashanti Region schools did not have hot holding equipment and temperature probes, although most had freezers. There were no records or documentation available on existing equipment temperature control in the Ashanti Region. Time and temperature control of ready to eat meals was by ensuring that source of fire (firewood or gas stove) was lowered or reduced until service time after cooking. Alternatively food was prepared and served on decided times to avoid cold food and or reheating after cooking from ambient storage. These were not standardised and random temperature checks of cooked food awaiting service had varying temperatures and times from the acceptable. The flow of products, food handlers and service were also significantly different among schools in the two countries. Unlike the Lincoln schools, schools in the Ashanti Region mostly lacked the linear flow of food in one direction to avoid cross contamination. The physical separation of kitchens into appropriate sections to avoid contamination risk was available but a few (20%) did not have these in the Ashanti Region schools. Pest control procedure was absent in the kitchens in Ghana for fear of food poisoning from the use of open market pesticides and self-administration by matrons. Some matrons reported to self-apply pesticides bought from open market when schools were on vacation and this defeated the aim of pest control. The absence of pest control was a hazard that required attention from management to curb food safety risks. Integrated pest and insect management was an intervention that was required in all the schools for their food storage areas and kitchens. Whilst the Lincoln schools had HACCP related Food Safety Management Systems, there was no evidence of FSMS in the Ashanti Region schools, HACCP was absent in all the 45 schools visited although both countries had qualified workers in charge of supervision or management of the kitchens. Nationality significantly affected the food safety management practice score in schools among the 55 schools used in the research. All the schools from Lincoln, UK scored between 90 – 100% whilst none of the Ashanti Region schools fell in this range. The schools in Ashanti Region of Ghana were between 20% and 89.9% with the highest score between 50-

69.9% (medium) for 75.7% of the 45 schools. Food safety in the Ghanaian schools required improvement as indicated by Afoakwa, (2005) and Ababio *et al*, (2012).

4.2.3 *Demographics of school kitchen matrons/managers and effect on food safety practices in Secondary Schools in Lincolnshire and Ashanti Region*

Out of the 55 secondary school matrons/managers sampled from Lincoln and Ashanti Region only 1 was a male and the other 54 (98.2%) were females (Fig 9). This supports other authors (Tomlins *et al*, 2002 and Addo *et al* 2007) report on the kitchen task being predominantly a female occupation.

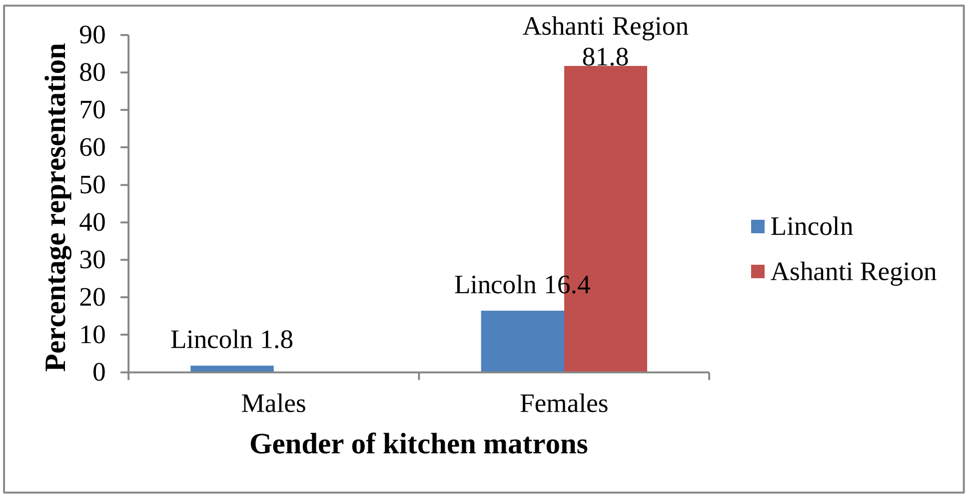


Fig 9. Gender of Secondary School matrons/managers in Lincoln and Ashanti Region

From Table 10, the age of matrons in Lincoln and Ashanti Region were significantly different. The highest age among matrons in Lincoln was between 40-49 years whilst that of matrons in Ashanti Region was 50-59 years. No matron in Lincoln was below the age of 30 but 3.6% of those in Ashanti Region were between 19-29 years. Academic qualification among matrons from both countries was also significantly different. A higher percentage (60.0%) of the matrons from Lincoln were diploma and first degree holders, the rest were secondary school leavers. Thirty one (31%) percent of the matrons from Ashanti Region were either diploma or first degree holders, 27% were secondary school leavers whilst (38%) were 706/1 or 706/1&2 holders from City and Guilds (Basic cookery or Advanced cookery certificate).

Table 10. Age, Academic and hygiene qualification of kitchen matrons or managers in secondary schools in Lincoln and Ashanti Region

			Age of kitchen matrons				
Country	19-29 years	30-39 years	40-49 years	50-59 years	60 years and over	Total	Chi square
Lincoln-UK	0.0	3.6	9.0	3.6	2.0	18.1	9.692(0.046)
Ashanti Region	3.6	23.6	9.0	42.0	3.6	81.8	
			Academic qualification				
Region	Secondary	City and guilds 706/1& 2	HND	First Degree	No response	Total	Chi square
Lincoln UK	9.1	0.0	5.5	3.6	0.0	18.2	95.886(0.001)
Ashanti Reg.	21.8	31.0	20.0	5.4	3.6	81.8	

Information on 45 matrons from Ashanti Region and 10 from Lincolnshire in percentages

The City and Guilds qualification was held by the older matrons (50 years and above) among the sampled schools in Ghana. University education among the two countries for the role of kitchen matron or manager was however low with Lincoln having 20% of the 10 matrons and Ghana, 6.6% out of 45 matrons. Level of education among matrons was low in terms of academic qualification as reported by Tomlins *et al*, (2002), Ackah *et al* (2011) and Ababio *et al* (2012).

4.2.3.1 *Effect of academic qualification and hygiene training on food safety management scores*

Whilst there was no significant difference (p=0.223) in the academic qualification of kitchen matrons and their school's food safety management scores (Table 11), their food hygiene training and qualification significantly affected their food safety management scores (p= 0.025). A matron might have higher academic qualification but without food hygiene qualification, food safety management could be negatively affected. Thus the knowledge on food hygiene, certification, sanitation training and awareness significantly affected food safety management scores as also reported by Hwang *et al,* (2001) and Henroid and Sneed, (2004).

Food hygiene training and qualification which is a requisite prerequisite measure for supervisors by Food Laws in both countries, the Ghanaian Public Health Act 851 (FDA 2012), the 1992 Food and Drugs Law of Ghana, and 1990 Food Safety Act of UK, (FSA, 1990) and Codex Alimentarius, (2009) was still lacking among some matrons in Ghana.

Table 11. Kitchen matrons academic and hygiene qualifications and effect on food safety management scores reported in percentages

	Food safety management score						
Academic qualification of matrons	0.0-19.9%	20.0-49.9%	50.0-69.9%	70.0-89.9%	90.0-100%	Total	Chi square
Secondary Education	0.0	1.8	12.7	7.3	9.1	30.9	18.803(0.223)
HND	0.0	1.8	14.5	3.6	5.5	25.5	
First degree	0.0	1.8	3.6	0.0	3.6	9.0	
City guilds	0.0	0.0	27.3	3.6	0.0	31.0	
No response	0.0	0.0	3.6	0.0	0.0	3.6	
	Food safety management score						
Food Hygiene qualification	0.0-19.9%	20.0-49.9%	50.0-69.9%	70.0-89.9%	90.0-100%	Total	Chi square
Yes	0.0	3.6	47.3	5.5	18.2	74.6	9.365(0.025)
No	0.0	1.8	14.5	9.1	0.0	25.4	

(0.0-19.9)% - Very poor, (20-49.9) % - Poor, (50-69.9) % - Medium, (70-89.9) % - Good, (90-100) % - Excellent

There were 31.1% matrons among the 45 sampled from Ashanti Region of Ghana who had no hygiene qualification. The amended food law in Ghana; the Public Health Act (2012) and the 1992 Food and Drugs Law (PNDCL 305B) both require persons in supervisory role to have enough knowledge and qualification in food hygiene to be able to produce wholesome food. The Section 5.6 of Codex Alimentarius Basic Hygiene Test (WHO/FAO 2009) equally requires people in management position to have enough knowledge of food hygiene principles and practices to be able to judge potential risks and make effective decision on control measures and corrective actions. This calls for a review on the qualification for matrons in Ghanaian schools in order to improve on food safety and its management. Mandatory refresher programmes and continuous training on food hygiene and food safety practices for matrons and food handlers were required in Ghana.

4.2.3.2. *Availability of Food Safety Management Systems and challenges envisaged by matrons in adopting HACCP in schools*

All the 10 schools in Lincoln had HACCP related food safety management systems in place. These were Safe Food Better Business or HACCP, confirming Food Standards Authority in the UK's report on available FSMs and simplified versions for kitchen managers (FSA, 2007). There was no FSMs or HACCP in the kitchens in Ashanti Region (Table 11), confirming absence or low levels generally in Ghana by Johnson *et al* (2008) and Ababio *et al* (2012). A single documented Prerequisite Programme (PRP) that was available was supplier control which was handled by Procurement officers and stores whilst matrons used open market for other perishable ingredients. The evidence for this PRP was a ledger on intake and usage however the ledger required an amendment as there was no provision for the confirmation of the shelf life of food ingredients received. Matrons had no culture of recording information on kitchen food preparation procedures in Ashanti Region, supporting Deddey-Agyei's report on the overlooking of documentation in Ghana by food handlers (GNA, 2008).

Table 12. Presence of FSMs in Lincolnshire and Ashanti Region Secondary Schools reported in percentages

	Food Safety Management Availability			
Region	Yes	No	Total	Chi square
Lincoln-UK	18.2	0.0	18.2	55.000(0.001)
Ashanti Region	0.0	81.8	81.8	
	Documentation of Prerequisite Programmes			
Region	Yes	No	Total	Chi square
Lincoln-UK	18.2	0.0	18.2	55.000(0.001)
Ashanti Region	0.0	81.8	81.8	
	Hygiene qualification of kitchen managers/matrons			
	Yes	No		
Lincoln-UK	18.2	0.0	18.2	4.173(0.041)
Ashanti Region	56.4	25.4	81.8	

Table is in percentage of matrons (55)

Some of the challenges matrons envisaged on adopting HACCP included lack of time, lack of finance, lack of infrastructure, lack of interest as there was no problem in schools, lack of technical personnel and awareness and a combination of the above as indicated on Figure 10. These have also been reported by King (1992), Hwang *et al* (2001), Giampoli *et al* (2003), Webb and Hubbard (2006). Lack of infrastructure and technical knowhow were predominant. These and finance could be beyond kitchen matrons jurisdiction hence school administrators and Government intervention was needed. Resource availability and education were external factors affecting good hygiene practices in schools. Lack of interest however is a motivational issue and recommended solutions including pressure from the Legislature and consumers (Panisello and Quantick, 2001) for standard operating procedures, mandatory hygiene training and regular surveillance towards improved practices with increased publicity on foodborne disease cases from the media. Consumer awareness and improved reporting culture could also create the need for improved practices.

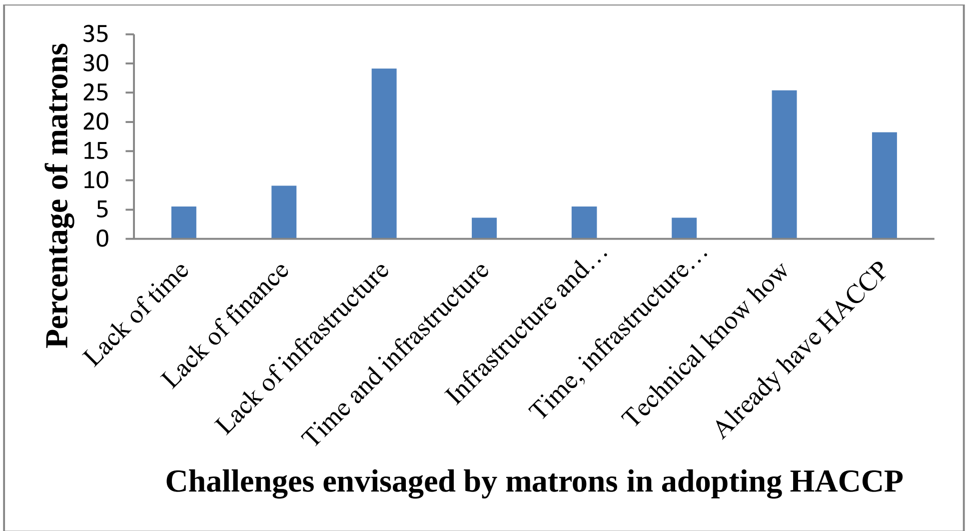


Fig 10. Barriers and challenges envisaged by kitchen matrons in adopting HACCP

Lack of time and interest among matrons needed a redress as this was based on lack of awareness of the dangers poor hygiene could cause the schools. Matrons were of the illusion that current practices were safe. This agrees with Afoakwa, (2005) who reported that school kitchen staff in Ghana did not consider food safety as a problem in their practices. Increased external pressure from government, customers (students), media and surveillance agencies for better standards was required to motivate kitchen matrons to improve on good hygiene practices in schools. From Table 5, over 50% of the students sampled had some form of food related illness during school term and from Figures 6 and 8, physical contaminants in school meals and food allergy and or intolerance were predominant in the Senior Secondary Schools visited in Ghana. Considering high staff numbers in Ashanti Region schools, a proper planning of task in kitchens through work study and work schedules with training and available suitable monitoring equipment could help matrons address the current issues especially with cleaning procedures which requires immediate intervention in the Ghanaian schools**.**

4.2.4. *Secondary School kitchen staff (cooks and pantry workers) demographics*

Kitchen staff sampled from all the 55 schools were predominantly females with only 6.2% being males. Gender differences in the two countries for kitchen staff were not significantly different. These 6.2% males were all from Ashanti Region and were responsible for food service and cleaning in kitchens.

Table 13. Gender of staff, hygiene qualification and medical screening before employment

			Gender of staff		
Region	Male	Female	No response	Total	Chi square
Lincoln-UK	0.0	6.2	0.0	6.2	0.356(0.853)
Ashanti Region	6.2	87.6	0.0	93.8	
			Hygiene training and qualification		
Region	Yes	No	No response	Total	Chi square
Lincoln-UK	5.7	0.5	0.0	6.2	61.056(0.001)
Ashanti Region	8.8	85.0	0.0	93.8	
			Medical screening before employment		
Region	Yes	No	No response	Total	Chi square
Lincoln-UK	0.5	5.7	0.0	6.2	2.452(0.002)
Ashanti Region	55.7	37.1	1.0	93.8	

Data on180 staff from Ashanti Region and 12 from Lincolnshire schools in percentages

Hygiene training was highly part of food safety management practice and hence only one staff member from Lincoln did not have a food hygiene qualification. On the other hand most staff in Ashanti Region SHS kitchens had no food hygiene training. Only 9.4% from the 180 kitchen staff from Ashanti Region had food hygiene training and these were predominantly assistant matrons or supervisors. Thus training of kitchen staff among the two countries was significantly different. This supports Ababio *et al* (2012) report on the absence of food hygiene training for the food industry in Ghana. Health screening of staff to declare fitness for work as part of employment requirement was practiced in Ghana but not a requirement in the UK. Only 1 staff from Lincoln reported of undergoing health check before being taken for the cooking job, whilst in Ashanti Region a higher percentage of staff had undergone health check before starting their cooking occupation. There was a significant difference among the two localities on health screening before employment. Routine screening was however practiced in both Lincoln and Ashanti Region with Environmental officers predominantly visiting schools in Ghana for this task

Table 14. Academic qualification of kitchen staff (cooks and pantry workers)

	Academic level					
Region	**Basic education**	**Secondary/Advance catering**	**HND**	**None**	**Total**	**Chi square**
Lincoln-UK	1.5	4.2	0.5	0.0	6.2	19.111(0.001)
Ashanti Reg.	65.6	16.7	2.1	9.4	93.8	

Data on180 staff from Ashanti Region and 12 from Lincolnshire schools in percentages

The highest Academic qualification among the working group in school kitchens was Higher National Diploma. Kitchen staff from Lincoln were predominantly secondary school leavers whilst those from Ashanti Region were with Basic education or dropouts. There were staff from Ashanti Region who had no formal education. Those with Advance catering qualification or HND from Ashanti Region were supervisors or assistant matrons. Academic qualification among staff from Lincoln and Ashanti Region were significantly different with 75% of staff from Ashanti Region having only basic education or no formal education. This supports report from Tomlins *et al*, (2002), Addo, (2005), Ackah *et al* (2011), and Ababio *et al* (2012) on the low level of education among food handlers in Ghana, cooking from Table 14, seems to be a job without any demand for higher academic qualification.

4.2.4.1 *Personal hygiene practices requirement scores among Lincolnshire and Ashanti Region Secondary School kitchen staff*

Unlike staff in Lincoln school kitchens, rigorous hand washing culture was not practiced by 11 % of the staff from Ashanti Region before food preparation, whilst 35% were likely to wash hands before food preparation and only 54% of the 180 staff were sure to wash their hands.

Table 15. Kitchen staff food hygiene practices in Ashanti Region and Lincolnshire schools

	Hand washing before starting food preparation						
Region	Most likely	Likely	Don't know	Unlikely	Most unlikely	Total	Chi square
Lincoln-UK	6.2	0.0	0.0	0.0	0.0	6.2	9.747(0.021)
Ashanti Region	50.5	32.8	0.0	10.0	0.5	93.8	
	Removal of unapproved jewellery during food preparation and service						
Region	Most likely	Likely	Don't know	Unlikely	Most unlikely	Total	Chi square
Lincoln-UK	5.73	0.52	0.00	0.00	0.00	6.2	12.962(0.005)
Ashanti Region	36.46	35.42	0.00	17.19	4.69	93.8	
	Staff reporting infectious diseases to matron/manager						
Region	Most likely	Likely	Don't know	Unlikely	Most unlikely	Total	Chi square
Lincoln	6.2	0.0	0.0	0.0	0.0	6.2	25.600(0.001)
Ashanti Region	27.0	38.5	6.2	16.1	6.0	93.8	
	Return to work 48 hours after recovery from gastroenteritis						
Region	Most likely	Likely	Don't know	Unlikely	Most unlikely	Total	Chi square
Lincoln- UK	6.2	0.0	0.0	0.0	0.0	6.2	25.600(0.001)
Ashanti Region	27.0	30.2	12.1	21.4	3.1	93.8	

Data on 180 staff from Ashanti Region and 12 from Lincolnshire schools in percentages
Most likely=5, Likely=4, Don't know=3, Unlikely=2 and Most unlikely=1

Some staff considered having bathed in the morning from their homes as sufficient hand hygiene to begin work. Rigorous hand washing practices is reported to reduce common colds by 33% and diarrhoea cases by 50% in care homes in the United States (Springer 2009). It is considered the single most important and inexpensive measure in controlling infection but it is still under practiced in Ashanti Region. The wearing of unapproved jewellery during food preparation and service is considered unhygienic as ornaments could fall into food causing physical hazards and also could contaminate food due to microorganisms that lodge in the crevices of jewels (Codex Alimentarius, 2009). Whilst all staff in Lincolnshire were most likely or likely to remove their jewellery before work, 21.8% of kitchen staff from Kumasi reported they were not likely or most unlikely to remove them during food preparation. The lack of awareness of the demands of GHP was evident among some staff in Ashanti Region schools. Matrons rather adorned themselves with jewellery and characteristically avoided covering their hair in all the schools visited in Ghana. Rheinlander *et al* (2008) had earlier reported that the aesthetic values including adorning of self by food handlers was considered a measure of good food safety practice thus ignoring salient practices like handwashing, cleanliness of the environment and pest control. It is a legal requirement for staff to report to management, infectious or potentially infectious conditions they could be suffering from and it is management responsibility to exclude such staff from working with food during such conditions (Food Safety Act of UK, 1990, Codex Alimantarius, 2009). Here staff from Ashanti Region SHS kitchens dealt with their diarrhoea conditions differently. Whilst 70% were most likely or likely to report, the rest managed the condition on their own. Twenty three percent (23.3%) took medication and returned to work same day as they felt better. Others had not experienced it and would not know what to do under such conditions. This was similar to the Indian report where 36.7% of 60 kitchen staff in a hospital would report to work with vomiting and diarrhoea symptoms (Anuradha and Dandekar, 2014). Out of the 180 staff from Ashanti

Region only 61.1% were sure to have been given days to stay at home until 48 hours after recovery from these symptoms (Table 15). This supports Sumner *et al* (2011) who reported that absence of policies requiring workers to report sickness to managers encouraged staff to work whilst suffering from diarrhea and vomiting symptoms. In the Ghanaian case salaries are paid monthly instead of hourly wages hence the absence of sick leave with pay as reported by Sumner *et al* (2011) would not have been a factor although some matrons during training indicated that the free meals for staff encouraged them to come to work even when they were sick. The lack of food hygiene training which keeps staff informed on good hygiene practices could subject students to unsafe food in schools and required intervention.

4.2.4.2 Effect of academic qualification of kitchen staff on their food hygiene awareness and food hygiene practices requirement scores

Table 16. Effect of kitchen staff academic qualification on food hygiene

	Personal hygiene requirement scores							
Staff Academic qualification	0.0-50.0%	51.0-60.0%	61.0-70.0%	71.0-80.0 %	81.0-90.0 %	>90.0 %	Total	Chi square
Primary education	1.6	17.7	34.0	8.3	4.8	1.0	67.4	52.264(0.002)
Secondary/Advance catering	0.0	4.7	5.2	5.7	3.1	2.0	20.7	
HND	0.0	1.0	0.5	0.5	0.5	0.0	2.5	
None	0.0	2.6	6.3	0.5	0.0	0.0	9.4	

	Food hygiene awareness test scores							
Staff Academic qualification	0.0-50.0%	51.0-60.0%	61.0-70.0%	71.0 80.0 %	81.0-90.0 %	>90.0 %	Total	Chi square
Primary education	64.1	2.8	0.5	0.0	0.0	0.0	67.4	62.131(0.001)
Secondary/Advance catering	14.1	3.6	2.5	0.5	0.0	0.0	20.7	
HND	1.0	1.5	0.0	0.0	0.0	0.0	2.5	
None	9.4	0.0	0.0	0.0	0.0	0.0	9.4	

(0.0-19.9)% - Very poor, (20-49.9) % - Poor, (50-69.9) % - Medium, (70-89.9) % - Good, (90-100) % - Excellent. Data is on percentage scores of 192 kitchen staff from Lincoln and Ashanti Region

There was a significant difference between the academic qualification of kitchen staff and their personal hygiene requirement and hygiene test scores. For personal hygiene requirement scores, none of the secondary school leavers and above had 'very poor' score although some primary school leavers were in this category. Personal hygiene awareness scores improved with education. All staff with no formal education (100%) and a higher percentage of staff with primary education (95.1%) scores were in the very poor category on food hygiene test (Table 16). Although general performance of staff on food hygiene test needed improvement, those with some academic qualification significantly outperformed the non-educated staff. Thus formal education significantly affected the level of good hygiene practice (p=0.002) and level of awareness (p=0.001) among kitchen staff, supporting Hwang *et al*, (2001), Henroid and Sneed, (2004) and Santana *et al*, (2009) report.

4.2.4.3 Effect of hygiene training of kitchen staff on food hygiene awareness and food hygiene practices requirement scores

Personal hygiene requirements and food hygiene awareness scores were significantly different among staff with food hygiene training or qualification and those without (Table 17).

Table 17. Kitchen staff food hygiene qualification and effect on awareness and practices

			Personal hygiene requirement scores					
Staff hygiene qualification	0.0-50.0%	51.0-60.0%	61.0-70.0%	71.0-80.0%	81.0-90.0 %	>90.0 %	Total	Chi square
Yes	0.0	0.5	4.2	3.1	4.7	2.0	14.5	45.817(0.001)
No	1.6	25.5	41.7	12.1	3.6	1.0	85.5	
			Food hygiene awareness test score					
Staff hygiene qualification	0.0-50.0%	51.0-60.0%	61.0-70.0%	71.0-80.0%	81.0-90.0 %	>90.0 %	Total	Chi square
Yes	7.3	4.1	3.1	0.0	0.0	0.0	14.5	72.007(0.001)
No	81.3	3.6	0.0	0.5	0.0	0.0	85.5	

Data on 180 staff from Ashanti Region and 12 from Lincolnshire schools in percentages
Very poor- (0.0-19.9)%, Poor- (20-49.9) %, Medium- (50-69.9) %, Good- (70-89.9) %, Excellent- (90-100)%

A higher percentage score for food hygiene practice requirement among staff with no hygiene training were between 0.0-50.0% and 61.0-70.0%, whilst the opposite was true for those with some food hygiene training. Food hygiene awareness score was also significantly different among those with and those without hygiene qualification. Whilst 95% of those without previous hygiene education scored between 0-50% only 51% of those with some hygiene training fell in this range. Henroid and Sneed (2004) reiterated that employee food hygiene training corresponded with high food safety score, p=0.030. From Table 17 staff hygiene training positively affected their food hygiene awareness and requirement scores (p=0.001).

4.2.5 *Summary*

Whilst hygiene standards in Lincolnshire were excellent the same could not be said of the Ashanti Region of Ghana. Forty nine percent (49%) of the schools were poorly designed, 80% did not have suitable toilets facilities (availability, proximity and properly maintained). A common tap area for hand washing and cleaning of utensils was not suitable. Maintenance culture was absent and utensils were stored in poorly maintained areas. Cleaning procedure was not standardised and supervision was lacking. Staff personal hygiene required improvement in hand washing practices, usage of unapproved jewellery, infectious disease management and protective uniform usage. Soap was not readily available for hand washing. Staff training was absent which was evident in the low hygiene awareness and personal hygiene requirement scores. Food Safety Management was absent and although it is a legal requirement for food establishments to have supervisors with requisite knowledge for their roles, 25.4% of matrons in the Ashanti Region did not have hygiene qualification whilst all matrons from Lincolnshire had hygiene qualification. Some matrons exhibited lack of motivation in adopting GHP and HACCP as according to them their current practices were safe. The report from section 4.1 and 4.2 however presented a contradictory information hence there was the need for external pressure through increased surveillance by the responsible state agencies, media coverage and student awareness and improved reporting culture on foodborne infections.

4.3 SHS kitchen audit and school hygiene categorisation in Ashanti Region of Ghana.

Microbiological assessment of school kitchen meals and environment to ascertain food safety was conducted based on pre-auditing and categorising the schools by hygiene standards. Pre food hygiene training auditing was conducted as part of the initial assessment of food hygiene standards among SHS kitchens in the Ashanti Region of Ghana. Auditing check list (Chapter 3 Section 3.3.2 and Appendix 1) was divided into 5 parts.


Plate.13 and 14. Condition of dining hall and dining furniture in Poor verses Medium hygiene category kitchens

Part one (P1) looked at facility design, part two (P2), utensils and equipment maintenance, P3 was on employee personal hygiene, P4 on quality of raw and ready to eat food and P5 on flow of production/handler/service and quality control. Categories were; very poor, poor, medium, good and excellent standards. Based on mean scores (Table 18a) there were no ‘very poor’ and ‘excellent’ hygiene standard schools in Ashanti Region. Table 18b shows that out of the 45 schools sampled 8.9% fell into poor category for over all mean score, 73.3% were medium, and 17.8% were good. For P1 (Facility design), 21 schools (46.7%) were poor, 44.4% were in medium category, 6.7% were good and only 1 (2.2%) was excellent. This supports Santana *et al* (2009) on poor kitchen facility design in public schools (Plates. 13 and 14).

Table 18a. Food hygiene standard categories among schools from Ashanti Region.

School Code	P1 (K= 10)	P2 (K=15)	P3 (K=25)	P4 (K=20)	P5 (K=30)	Mean score	Hygiene category
OO7	7.8	15.0	25.0	10.0	26.8	8.4	Good
O10	6.0	6.8	25.0	10.0	27.0	7.4	Good
O19	4.0	9.7	25.0	10.0	22.9	7.1	Good
O26	9.5	11.8	25.0	10.0	26.4	8.2	Good
O36	7.2	6.8	25.0	10.0	22.9	7.1	Good
O38	4.5	11.8	23.4	10.0	22.9	7.2	Good
O39	5.5	10.6	25.0	10.0	26.4	7.7	Good
O42	4.7	9.3	25.0	12.0	20.5	7.1	Good
OO2	8.4	14.3	18.7	10.0	17.1	6.8	Medium
OO3	5.5	2.5	18.7	10.0	21.9	5.8	Medium
OO5	4.1	3.4	18.7	10.0	17.3	5.3	Medium
OO6	5.5	7.5	25.0	10.0	15.8	6.3	Medium
OO8	5.0	2.5	25.0	10.0	16.5	5.9	Medium
OO9	6.0	5.2	25.0	10.0	18.5	6.4	Medium
O11	4.3	4.3	25.0	10.0	22.9	6.6	Medium
O12	6.8	6.7	25.0	6.6	23.6	6.8	Medium
O13	4.6	7.5	25.0	10.0	12.7	5.9	Medium
O14	5.0	3.3	25.0	10.0	19.5	6.2	Medium
O15	5.6	7.5	21.8	10.0	20.5	6.5	Medium
O16	3.4	2.5	25.0	10.0	20.7	6.1	Medium
O18	6.8	7.5	17.1	10.0	26.8	6.8	Medium
O21	4.2	3.7	25.0	9.3	22.9	6.5	Medium
O22	4.2	9.3	25.0	10.0	19.4	6.7	Medium
O23	5.9	5.4	12.5	10.0	17.3	5.1	Medium
O24	5.6	6.2	21.8	10.0	22.9	6.6	Medium
O25	4.0	6.2	14.5	10.0	18.3	5.3	Medium
O27	5.2	10.0	23.0	10.0	19.4	6.7	Medium
O28	5.4	5.0	25.0	10.0	16.1	6.1	Medium
O29	6.6	8.1	9.3	10.0	22.9	5.6	Medium
O30	5.0	11.2	15.6	10.0	12.3	5.4	Medium
O31	6.4	7.1	25.0	10.0	15.8	6.4	Medium
O32	5.4	5.0	18.2	10.0	22.9	6.1	Medium
O33	4.3	4.5	21.8	10.0	19.4	6.0	Medium
O34	3.8	9.3	17.1	10.0	19.4	5.9	Medium
O35	2.9	3.7	18.7	10.0	19.4	5.4	Medium
O37	4.0	9.3	23.4	10.0	22.9	6.9	Medium
O40	3.6	5.0	22.9	10.0	8.8	5.0	Medium
O41	4.3	7.1	25.0	10.0	22.9	6.9	Medium
O43	5.7	6.0	25.0	10.0	16.6	6.3	Medium
O44	5.2	10.6	17.1	10.0	22.9	6.5	Medium
O45	2.0	7.5	25.0	10.0	22.9	6.7	Medium
OO1	4.5	4.7	15.6	12.0	12.8	4.9	Poor
OO4	3.5	2.5	21.0	10.0	12.3	4.9	Poor
O17	3.3	2.5	21.8	5.0	10.0	4.2	Poor
O20	4.0	5.0	17.1	10.0	6.5	4.2	Poor

Table 18b. Summary on schools categorisation in Ashanti Region of Ghana

		Range of audit scores						
Hygiene category	**Number of schools**	**P1** (K= 10)	**P2** (K=15)	**P3** (K=25)	**P4** (K=20)	**P5** (K=30)	**Mean score range**	**Percentage (%) of schools**
Good	8	4.0-9.5	6.8-15.0	23.5-25.0	10.0-12.0	20.5-27.0	7.1-8.4	17.8
Medium	33	2.0-8.4	2.5-14.3	9.3-25.0	6.6-10.0	8.8-26.8	5.1-6.9	73.3
Poor	4	3.3-4.5	2.5-5.0	15.6-21.8	5.0-12.0	6.5-12.8	4.2-4.9	8.9

P1- facility design, P2- utensils and equipment maintenance, P3 -employee personal hygiene
P4- quality of raw and RTE food, P5- flow of production/handler/service and quality control
P = (TS/$\sum_1$-$\sum_2$) x K = score of each part evaluated
TS = Total points obtained, $\sum_1$ = Total number of possible points, $\sum_2$ = Total number of points not applicable
Mean score = P1+P2+P3+P4+P5/10.
Excellent (9.0-10.0), Good (7.0-8.9), Medium (5.0-6.9), Poor (2.0-4.9), Very poor (0-1.9)

The main issues were lack of proper design, access to unauthorised persons and animals, lack of properly maintained floors, lack of proper waste management, absence of pest control, absence of wash basins and suitable hand hygiene products. P2 was for utensils and equipment maintenance and 11.1% of the schools were in the very poor category, 22 schools (49%) were poor, 24.4% were medium, 11.1% were good. Only 2 schools (4.4%) were excellent. The main issues in the schools on utensils and equipment maintenance were lack of standardised cleaning procedure, absence of sanitizers, lack of proper storage area for utensils (Plate 15 and 16) and absence of maintenance culture. None of the schools had hot holding equipment for cooked food, subjecting cooked food to possible temperature and time abuse with the risk of food borne illness to students (Afoakwa, 2005).

With employee personal hygiene (P3), only one school (2.2%) was in the poor category, 17.8% were medium, 24.4% were good and 55.6% were excellent. This looked at the use of suitable uniforms, personal cleanliness (short nails, without polish and adornment), hand washing before manipulation and after toilet and control of staff health. Some kitchen staff still wore jewellery during food preparation and service and surprisingly some matrons and their assistance were involved in this practice. Usage of protective clothing or uniforms and hand washing culture was not adhered to mostly due to lack of management commitment in providing the needed equipment and materials. Some staff were spotted wiping their washed hands in their dresses or uniforms after cleaning which contaminated their washed hands. Staff health check was in place and controlled by the Environmental Health Agency of Ghana although records were not kept.

With the quality of raw and ready to eat food (P4) none of the schools fell in the good or excellent category.

Plate 15and 16. Storage of serving pans under a good verses medium hygiene category kitchens

Three schools (6.7%) were poor and 93.9% were medium. The main issues were lack of properly controlled origin of raw materials and supplier control. Open market was still practiced for some food items among all the sampled schools with the exception of one. Quality control of food items (records keeping, temperature control, supplier control and auditing) was lacking supporting Panisello *et al* (2000) and Santana *et al* (2009). Procurement officers were in charge of receiving supplier controlled items but there was no evidence on the control and monitoring of safety of the products (shelf life and temperature) in all the schools. Goods receiving ledgers handled by procurement officers had no column for these either. Finally, for P5 (Process flow and Quality control), 15.6 % of the schools were poor, 42.2% were medium, 40% were good and only 1(2.2%) was excellent. The main issues were absence of hot holding equipment, lack of properly designed kitchen affecting product flow and lack of protection against insects and pest ingress. All the 45 schools surveyed had qualified persons (matrons) in supervisory position. Laboratory test for food microbiology for quality and safety was not applicable in all the schools. Four schools were selected from each category for food quality and safety assessment.

4.3.1 *Microbiological assessment of food, food time and temperature profile*

Microbiological quality, temperature of food at service and holding time after service to students meal time were studied as part of kitchen audit after categorising schools into Good, Medium and Poor hygiene standards. Ready to eat meals, jollof rice the most popular meal among sampled students (66.7%) and groundnut soup the second most popular (15.6%) were chosen for the study.

4.3.1.1 Jollof Rice microbiological assessment, food time and temperature profile

Plate 17. Jollof rice

The temperature of Ready-to-Eat food is expected to be held at the hot holding temperature of 63 ℃ (Sprenger, 2009) to ensure that microorganisms that survive cooking are not able to grow to unacceptable levels. The mean temperature of jollof rice (Plate 17), plain rice or rice meals (rice cooked with vegetables and sometimes fish, meat or cowpea) at service from the good hygiene category schools alone was above this temperature 46 minutes into dining time (Table 19). Both medium and poor hygiene category schools had average food temperatures below

63℃ (57.0±5.96 – 59.50±7.36 ℃) with the poor category schools mean time to dining at almost an hour with a higher standard deviation of ± 37.83 (minimum 27min and maximum 100min into dining time). The hot holding temperature of 63℃ is reported to be attainable in an uncontrolled environment within a food holding time of 60 minutes after cooking (Dablool *et al*, 2014). From Table 19, only 36.4% of the schools had this temperature at service and all the schools had additional time between service and meals thus there were remarkable excesses in food temperature and time abuse.

Table 19. Mean food (jollof rice) holding temperature and time at sampling and microbiological quality in $Log_{10}CFU\ g^{-1}$

Hygiene category	**School code**	**Food temp. ^{O}C**	**Food service to dinner time(Min)**	**ACC log_{10} CFU g^{-1}**	**Coliforms log_{10} CFU g^{-1}**	**Yeast & mould log_{10} CFU g^{-1}**	***S. aureus* log_{10} CFU g^{-1}**	***Bacillus cereus* log_{10} CFU g^{-1}**
GSS:955				4	2	3	2	2
Good	O26	68.50	30.00	3.91	3.29	3.46	2.00	2.78
	O19	61.50	60.00	3.00	2.58	4.10	2.77	2.85
	O10	59.50	57.50	2.98	2.99	2.27	2.15	2.27
	OO7	69.50	36.50	5.23	5.15	2.64	3.93	2.30
Mean		64.70 ±4.99	46.00 ±14.99	3.78 ±1.06	3.51 ±1.13	3.12 ±0.80	2.71 ±0.87	2.55 ±0.31
Medium	O12	57.50	47.50	5.29	4.52	2.15	3.82	4.15
	OO5	54.50	35.00	3.69	2.52	2.91	2.53	2.96
	OO3	65.00	75.00	5.80	3.07	2.65	4.12	3.47
	OO2	49.50	35.00	4.19	3.35	3.83	3.80	3.15
Mean		57.00 ±5.96	48.12 ±8.86	4.75 ±0.97	3.49 ±0.87	2.88 ±0.70	3.57 ±0.70	3.43 ±0.52
Poor	O20	55.50	27.50	3.08	2.50	3.00	3.21	3.50
	OO4	55.00	45.00	5.75	2.80	2.00	5.21	3.65
	OO1	68.00	100.00	6.60	6.02	3.73	4.31	5.10
Mean		59.50 ±7.36	57.50 ± 37.83	5.04 ±1.72	3.77 ±1.95	2.91 ±0.87	4.25 ±1.00	4.10 ±0.88
Grand mean		60.50 ±6.43	49.91 22.02	4.47 ±1.24	3.57 ±1.18	2.98 ±0.72	3.44 ±0.99	3.29 ±0.83

[a]log_{10} CFU= number of colony-forming units in logs

Panisello *et al* (2000) reported that 79.2% of all England and Wales food poisoning cases were due to temperature abuse. This was evident in the schools under study. As the meals were dished and kept in the open in aluminum pans awaiting student meal time, temperature could reduce further to unacceptable levels (Fig. 7). Thus as temperature and time of cooked rice is abused there is the possible growth of pathogenic bacteria and toxin production that cause food poisoning if cross contamination is not prevented. The mean temperature across the categories was however below the acceptable hot holding temperature. This could be because most kitchens prepare meals well in advance and meals were kept in kitchen in bigger pots with quenched fire for longer periods before dishing. This supports Santana *et al* (2009) where schools before GMP training had mean temperature of cooked food at service ranging from 40.6 ℃ ± 1.7 for poor hygiene school, 74.2 ℃ ±0.3 for medium, and 59.2 ℃ ± 1.4 for excellent schools. With grand mean temperatures of 58.0 ℃ and 60.5± 6.43 ℃ in Brazil and Ghana respectively, cooked RTE school food temperatures at service before intervention in both countries were not acceptable considering the holding times. The highest aerobic colony count, 5.04 ± 1.72 Log_{10} CFU g^{-1} was from the schools with poor hygiene category (Table 19) indicating low quality which could be caused either by poor handling practices and or temperature abuse (HPA, 2009). This was above the national reference level of 4 Log_{10} CFU g^{-1} for cooked food set by the Ghana Standard Authority in GS 955: 2013, and unsatisfactory for both international standards (ICMSF, 2005) and UK standards for ready to eat foods prior for sale or consumption with borderline given as 3 - < 5 Log and unacceptable limit at ≥ 5 Log_{10} CFU g^{-1} (HPA, 2009). It was however similar to 5.48± 0.97 Log_{10} CFUg^{-1} in cooked macaroni samples among food vendors in Kumasi (Feglo and Sakyi, 2012). The current result was also higher than the reported 3.52 Log_{10} CFU g^{-1} in jollof rice from sampled hotels in Accra-Ghana by Addo *et al*, (2007). Thus raising the question of whether food safety practices in schools in Ghana were better than in the commercial environment. Adolf and Azis, (2012) reported a similar level 5.88 $Log_{10}CFUg^{-1}$ of ACC in elementary school meals in Indonesia. The 3 $Log_{10}CFUg^{-1}$ mean ACC in cooked Ready-to-Eat meals in Brazil was lower than the Ghanaian 4.47 ± 1.24 log $CFUg^{-1}$ which was above the 4 log for cooked cereals set by the Ghana Standards Authority's, GS 955: 2013. The poor hygiene school in Brazil however had 5 $Log_{10}CFUg^{-1}$ in cooked RTE food (Santana *et al* 2009) which was similar to the Ghanaian poor hygiene category school's 5.04±1.72 $Log_{10}CFUg^{-1}$. The pattern of ACC levels agreed with the auditing scores as it decreased as hygiene improved.

The mean total coliforms across the categories was between 3 - < 4.0 log_{10} $CFUg^{-1}$ and a grand mean of 3.57 ± 1.18 $log_{10}CFUg^{-1}$ which was above the satisfactory level of 2 $Log_{10}CFUg^{-1}$ of the GS 955:2013 of Ghana and of ICMSF (2005). Due to their heat sensitive nature their presence signifies post processing contamination which could be faecal from handlers or from the environment signifying poor handling, poor hand washing culture and cleaning practices (Mead, 2007). This supports the audit outcome of the lack of proper hand washing with soap in the schools. There were both lactose fermenting and non-lactose fermenting types observed which could include the genus *Escherichia* and *Salmonella* respectively which are pathogenic. Total coliforms ≥ 4 $log_{10}CFUg^{-1}$ are considered unsatisfactory by GS 955: 2013 of Ghana and by ICMSF (2005) which gives satisfactory level of 2Log_{10}CFU g^{-1} for coliforms in ready to eat food. All the hygiene categories had mean total coliforms above 2 log_{10} $CFUg^{-1}$ but below 4Log, thus within borderline which could reach unsatisfactory levels (≥ 4 $Log_{10}CFUg^{-1}$) with current practices. This was an indication of possible evidence of poor hygiene due to cross contamination from food handlers, food contact surfaces and poor temperature and time control (HPA, 2009). One school from each category had unsatisfactory level of coliforms in jollof rice with the highest of 6 Log from poor hygiene category (school 001), 5 Log from good hygiene category (school 007) and 4 log from medium hygiene category (school 012). This calls for a review of cooking and all hygiene procedures including cleaning. The acceptable level for the pathogens, *E. coli* and *Salmonella* in ready to eat meals are 1.3 - < 2.0 Log_{10} $CFUg^{-1}$ and absent in 25g respectively (Sprenger, 2009, ICMSF, 2005) hence students could be subjected to the risk of foodborne diseases due to poor food handling practices if present. The highest coliform level 6 Log_{10} CFU g^{-1} reported in this work was higher than levels in noodle and chicken meal with highest coliform count of 5 Log_{10} CFU g^{-1} from school meals in Indonesia (Adolf and Azis, 2012) and 1.51 Log_{10} MPU g^{-1} reported by Santana *et al* (2009) in macaroni with raw vegetable from schools in Brazil. Total coliforms levels in jollof and cooked rice from the schools did not follow the pre audit outcome.

The highest average yeast and mould count was from the Good hygiene category schools (3.12 ± 0.8 log_{10} $CFUg^{-1}$) and this was above the satisfactory level of 3 log_{10} CFU g^{-1} of the GS 955:2013 of Ghana and of ICMSF (2005) but was similar to the yeast and mould level of 3.3 log_{10} CFU g^{-1} in rice from ready to eat shops in Argentina, reported by Sousa *et al* (2002). All the hygiene categories had a school with yeast and mould levels in food above the national acceptable level. Yeast and mould are potential spoilage organisms and a high count could mean food spoilage. The risk of the presence of mycotoxins produced by mould is with the chronic toxicity and carcinogenic activity which could cumulatively render the consumer immunosuppressed with related organ damage (Blackburn and McClure, 2009).

Plate 18 and 19. Left: served food awaiting meal time stored in aluminium pans. Right: staff dishing rice into pans from bigger pots.

Hence a reduction in the current levels would help to prevent health risk. *Staphylococci* isolates included catalase positive, coagulase positive (9.10%) and predominantly coagulase negative (90.90%) *S. aureus*. The presence of *Staphylococcus aureus* in cooked meals indicates poor personal hygiene, staff talking over food during preparation and poor cleaning procedures in a kitchen. The mean count in jollof rice for *Staphylococcus aureus* was 3.44 ± 0.99 $\log_{10}$ CFU g^{-1}. This was above the national satisfactory level of 2 $\log_{10}$ CFU g^{-1} for ready to eat food by GS955:2013 of Ghana and ICMSF (2005) but below the unsatisfactory level of > 4 Log_{10}CFU g^{-1} which could be injurious to health (HPA, 2009). *S. aureus* generation time in cooked rice samples in Saudi Arabia was reported to be 102 minutes and highest growth rate was at an average temperature of 53.3℃ (Dablool *et al*, 2014) and lowest at 66.4 ℃ with enterotoxin production highest at 45℃. Even though with this present work coagulase positive *S. aureus* was not prevalently isolated in jollof rice, considering the levels of Staphylococci present, if by numbers these could be harmful to the human body, then the contamination risk could be injuries in the medium and poor hygiene category schools with highest levels at 4.12 and 5.21 Log_{10} CFUg^{-1} respectively with lower holding temperatures (≤ 63℃) and holding time ranging from 35 to 100 minutes. Whilst two poor hygiene category schools and one medium hygiene category school had levels of *Staphylococcus aureus* between 4 and >5 $\log_{10}$ CFU g^{-1}, all the schools in the good hygiene category schools had below 4 Log with one good hygiene school having the 2 $\log_{10}$ CFU g^{-1} which is the acceptable level for ICMSF (2005) and GS 955: 2013 of Ghana for ready to eat food. Level of *Staphylococcus aureus* contamination within the hygiene categories increased with poor hygiene practice although there was no significant difference among the groups ($p > 0.05$). Only schools with poor hygiene category had mean count of 4.2 ± 1.00 Log_{10}CFUg^{-1} which was above the acceptable level and could increase with poor time and temperature control to significant toxin producing levels > 5 Log_{10}CFUg^{-1} (HPA, 2009), causing intoxication among students, as food is served earlier and waits for up to 100 minutes for student's meal time. Feglo and Sakyi (2012) also reported *S. aureus* in macaroni sampled from Kumasi-Ghana food vendors and blamed it on non-standard hygiene practices of food handlers and water used during food preparation, however there were no *S. aureus* in jollof rice sampled from hotels in Accra-Ghana by Addo *et al*, (2007). Although jollof rice and cooked plain rice are less manually handled after cooking their coming into contact with poorly cleaned and poorly stored kitchen equipment, staff hands and saliva from talking could lead to contamination. Santana *et al* (2009) reported of high levels of coagulase positive *Staphylococcus aureus* in plain rice with canned meat balls above the 3 $\log_{10}CFUg^{-1}$ level set by the Brazilian government in a medium hygiene category school, which is similar for the medium category school in this study except that *Staphylococcus aureus* values were not above ACC values in this study. There was a negative correlation between temperature of food at service and levels of *Staphylococcus aureus* in food although this was not significantly different ($p > 0.05$). Thus as temperature of food increased *S. aureus* levels seemed to decrease vice versa. Food holding time (after cooking to meals) was however positively correlated with *Staphylococcus aureus* levels in food, thus the longer the food holding time of jollof rice after cooking the higher the level of bacteria in food. The longer stay of food after preparation before service and meal time in the absence of hot holding equipment could lead to intoxication as *S. aureus* produces toxin over longer storage in a conducive environment for microbial contaminants.

Bacillus cereus food poisoning is highly associated with temperature abused cooked rice as the uncooked rice could contain spores of the bacteria. Poor quality raw rice, inadequate processing temperatures, abused food holding temperatures and time could lead to *B. cereus* spore germination and growth of the vegetative cells in cooked rice and further food poisoning. The mean *B. cereus* values in cooked rice were 2.55 ± 0.31, 3.43± 0.52 and 4.10 ± 0.88 $Log_{10}CFUg^{-1}$ for Good, Medium and Poor hygiene category schools respectively. The levels of *Bacillus cereus* in jollof increased with decreasing good hygiene practices but were not significantly different among the categories ($p>0.05$), all the schools had values above the satisfactory level of 2 Log_{10} CFU g^{-1} set by Ghana Standard Authority's GS 955 (2013) and ICMSF (2005). The medium and poor hygiene category schools were within the border line of (3- ≤ 5 Log_{10} CFU g^{-1}) for ready to eat meals (HPA, 2009, ICMSF, 2005) though one school in the poor category had unsatisfactory levels (>5 Log CFU g^{-1}). This was a likely evidence of poor processing, poor quality raw materials or poor temperature control (HPA, 2009) and not personal hygiene issue. With a mean food temperature already at 59℃ and food still waiting for 57 minutes more before students meal time with food already dished into serving pans (Plate 18 and 19), *Bacillus cereus* spores with germination temperature range of 55-60℃ (Blackburn and MacClure, 2009) could geminate and vegetative cells rapidly increase with further cooling of cooked rice to unacceptable levels causing illness as reported by Wang *et al* (2014) and Nichols *et al* (1999). Unlike this study, Mensah *et al* (2002) worked on street food including rice and rice meals but did not report on *Bacillus cereus*, Addo *et al* (2009) did not also report on *Bacillus cereus* in rice and jollof in hotels in Accra, Ghana. However levels in cooked rice in this study could mean the organism is a potential food poisoning risk in cooked rice in Ghana. Wang *et al* (2014) reported that emetic toxins could survive cooking at 100 ℃ for 2 hours thus the presence of toxins in cooked rice could persist based on current practices which could lead to germination and growth of vegetative types when temperature and time of cooked rice are abused. Nichols *et al* (1999) studied cooked rice from restaurants and take-away premises in the UK and indicated that final heating could not inactivate emetic toxins although overall microbiological quality could be improved. Thus high levels of *Bacillus cereus* (5 Log_{10} CFU g^{-1}) could lead to preformed toxins that would lead to food poisoning with common symptoms including abdominal pain and vomiting reported by students (Tables 3 and 5) which could ensue same day after food consumption (Sanisa *et al* 2012). The sourcing of suitable suppliers for quality rice and temperature control as part of GHP could improve the current condition.

4.3.1.2. *Microbiological assessment of groundnut soup, time and temperature profile*

Plate 18. Groundnut soup

Groundnut soap has been associated with *Salmonella* contamination in street foods from Accra-Ghana (Mensah *et al* 2002). The soup made from peanuts butter with added vegetables and fish, meat or chicken could be a source of foodborne disease if processing and holding temperatures are not controlled. The highest temperature of groundnut soup (Plate 20) at service/sampling across the schools was 76.5 ℃ and lowest was 55℃, whilst lowest time from sampling/service to meals time was 4.5 minutes and highest was 75 minutes. Whilst mean temperature of groundnut soup at service across the schools and categories were > 63℃, poor category schools soups after service had to wait for more than an hour (66.2 min) before meals time. This could lead to soup growing cold as soups are served in pans without any control for temperature (Fig 12). Medium category schools served soup waited for 33.2 minutes and Good category schools served soup waited for 19.6 minutes. Food holding temperature and time from service to meal time were however not standardised in the schools and across categories which indicates lack of control and possible risk to consumers. Overall soup cooking in schools was started early and could be kept on fire when cooked with fire wood removed or gas lowered but not quenched without the risk of food burning until service time hence the higher temperatures as compared with jollof rice (Table 19). Meat or fish were however cooked separately, stored at ambient temperature and added to soup during dishing or service. This practice could be another source of contamination risk.

Table 20. Mean holding time, temperature and microbiological profile of groundnut soup

Hygiene category	School code	Soup temp. ℃	Service to dinner time (Min)	ACC log_{10} CFU ml^{-1}	Coliforms log_{10} CFU ml^{-1}	Yeast and mould log_{10} CFU ml^{-1}	*S. aureus* log_{10}CFU ml^{-1}	*Salmonella* spp.
GSS:955				4	2	3	2	ND
Good	O26	73.50	37.50	2.45	1.79	1.52	1.89	ND
	O19	59.50	6.50	1.72	1.65	2.15	1.00	ND
	O10	69.00	4.50	2.06	1.50	3.39	1.50	ND
	OO7	61.00	30.00	3.36	1.78	2.00	2.77	ND
Mean		65.75	19.63	2.40	1.68	2.26	1.79	
		±6.64	±11.62	±0.71	±0.13	±0.80	±0.74	
Medium	O12	67.50	35.50	1.84	1.92	1.57	1.65	ND
	OO5	55.00	43.50	2.29	2.09	1.37	1.89	ND
	OO3	76.50	45.00	3.69	2.67	2.44	2.62	ND
	OO2	59.50	9.00	3.72	2.55	1.42	1.75	ND
Mean		64.63	33.25	2.89	2.31	1.70	1.97	
		±9.46	±16.69	±0.96	±0.36	±0.50	±0.44	
Poor	O20	60.50	56.00	2.31	1.09	1.37	1.35	ND
	OO4	68.50	75.00	2.06	1.00	1.87	2.20	ND
	OO1	73.00	67.50	2.63	1.97	1.98	1.15	ND
Mean		67.33	66.17	2.33	1.35	1.74	1.57	
		±6.33	±9.57	±0.29	±0.54	±0.32	±0.56	
Grand mean		65.77 ± 7.02	37.27 ±23.80	2.56 ± 0.72	1.82 ± 0.52	1.92 ±0.60	1.80 ± 0.56	

ND= Not detected in 25 g

The highest ACC count for soup was 3.72 LogCFUml^{-1} from medium category schools and the lowest was 1.72 Log_{10}CFUml^{-1} from Good category school. However all the schools had values <4 Log thus falling within the acceptable levels set by the Ghana Standard Authority for all cooked food. This was similar to the report by Addo *et al* (2007) on food samples including soup from Hotels in Ghana and attributed it to the hot nature of soup during service. Santana *et al* (2012) found ACC above 5 Log_{10}CFUml^{-1} in soups from poor hygiene category schools in Brazil with serving temperatures at 40.6 ℃ ± 1.6 before GHP. In this work ACC for all the soups sampled were below 4 log_{10} and none had cooled to below 55.0 ℃. This was not so for jollof which when cooked earlier had temperature falling to below 50.0 ℃ before dishing as continuous stay on fire burned the rice, hence higher bacteria counts. Only schools in the medium category had coliform levels above the 2 Log_{10} set by GS 955:2013 of the Ghana Standards Authority (2013) but within the acceptable limits of 3log_{10}CFUml^{-1} used by Mensah *et al*, (2002) and Yeboah-Manu *et al* (2010) in their work in commercial settings in Accra. Soup due to the nature of processing did not seem to have contamination risk as compared to jollof rice. All but one school in the Good Category school had yeast and mould levels at 3.39 log_{10} CFU ml^{-1} which was a little above the acceptable levels in Ghana and ICMSF (2005). Only catalase positive and coagulase negative *Staphylococcus aureus* which are of the normal micro flora of humans were identified in all the soups. Each category had mean value of coagulase negative Staphylococci below the 2 Log_{10}CFUg^{-1} set in Ghana Standard Authority's GS 955:2013. The presence of these however indicated possible after cooking contamination as soups were cooked to temperatures that could not encourage the survival of vegetative cells. Pans, ladles, staff hands in contact with soups could be the source of contamination as shown from staff hands and food contact surfaces report. Addo *et al* (2007) also reported the absence of coagulase positive *Staphylococcus aureus* in soup sampled in hotels in Ghana although Mensah *et al* (2002) isolated *S*. aureus (0.3 ± 1.94 Log_{10}CFU g-^{1})

from groundnut soup in Accra street food. Santana *et al* (2012) also reported of the presence of the *S. aureus* in school food sampled in Brazil.

Salmonella was not detected in 25 g of groundnut soup samples tested in all the schools (Table 20). This was in line with the no detection level set by GS 955:2013 and was similar to Addo *et al* (2007), report on hotels in Accra, Ghana and Santana *et al* (2012) on schools in Brazil but unlike Mensah *et al* (2002) who found *Salmonella* in groundnut soups on their work on street foods in Accra, Ghana. Comparatively groundnut soup presented lesser risk to consumers in comparison to jollof rice and other cooked rice meals in the secondary schools sampled.

4.3.2 *Kitchen staff hand hygiene and microbial levels according to current practices*

Table 21. Microbiological contaminants on staff hands after washing – Pre intervention

		Microbiological counts in $Log_{10}CFUcm^{-2}$			
Hygiene Category	**School code**	**Pre GHP ACC**	**Pre GHP Coliforms**	**Pre GHP Yeast and moulds**	**Pre GHP *S. aureus***
Advisory guideline		1.3	1.0	1.0	1.0
Good	O26	2.79	2.37	2.00	1.71
	O19	3.61	3.55	2.11	2.92
	O10	1.72	5.71	0.12	3.78
	OO7	4.71	5.91	0.59	0.59
Mean		3.20±1.26	4.33±1.66	1.21±1.00	2.25±1.42
Medium	O12	5.71	5.71	0.76	3.23
	OO5	2.91	2.51	0.76	2.40
	OO3	5.22	6.71	0.44	3.70
	OO2	3.86	3.59	3.98	3.63
Mean		4.42±1.27	4.62±1.92	1.48±1.67	3.24±0.61
Poor	O20	3.32	1.88	1.12	1.35
	OO4	3.66	3.54	0.30	3.61
	OO1	5.70	5.71	2.09	3.02
Mean		4.23±1.29	3.71±1.91	1.17±0.91	2.66±1.17
Schools mean		3.92±1.28	4.27±1.68	1.31±1.15	2.72±1.08

Eleven kitchen staff from the eleven schools were randomly sampled and asked to wash their hands per each visit before their hand swabs were taken. Swabs were aseptically taken to the laboratory and analysed. Colony Forming Units cm^{-2} were calculated for ACC, total coliforms, yeast and mould and *Staphylococcus aureus.*

ACC load on staff hands ranged from 5.71-1.72 $Log_{10}CFUcm^{-2}$ with schools mean of 3.92±1.28 $Log_{10}CFUcm^{-2}$(Table 21). The highest ACC was from school O12 of medium hygiene category followed by school OO1 of poor hygiene category. Although Good hygiene category had the least mean ACC count (3.20±1.26) the microbiological count on staff hands did not follow the initial audit pattern as Medium hygiene category schools had the highest mean ACC on staff hands instead of poor hygiene category schools (Fig 11). Thus even though other factors like available infrastructure and resources may cause a facility to be categorized under a suitable hygiene standard, actual practices of staff might differ (Santana *et al* 2009) hence the higher microbiological contaminants on staff hands after washing in medium hygiene category schools. None of the schools met the advisory standard of 1.3 $Log_{10}CFUcm^{-2}$ proposed by Sneed *et al* (2004), Santana *et al* (2009) and Marzona and Balzaratti (2013).

In Brazil, poor hygiene category schools had lowest ACC on staff hands which was <3 $Log_{10}CFUcm^{-2}$ whilst both excellent and medium hygiene schools had > 6 $Log_{10}CFUcm^{-2}$ before GHP intervention (Santana *et al* 2009). This was contrary to the Ghanaian situation and none of the schools had ACC above 6 Log. Santana *et al* (2009) reiterated that the excellent schools during Pre GHP intervention audit had soap and antiseptic agents for staff to wash hands but they had the highest contamination blaming it on staff not adopting good practices. Tan *et al* (2013) reported of a mean of 1.56 ± 0.58 $Log_{10}CFUcm^{-2}$ on staff hands from primary schools in Malaysia which was far below the current values from Ghana. The current results from Ghana was also higher than South African food handlers in convenient food industries who had 3 $Log_{10}CFUcm^{-2}$ for ACC on hands (Lambrechts *et al* 2014) and those in schools in the same country where there was 30% satisfactory report (Nhlapo *et al* 2014). The use of water only as a cleaning agent has not been effective. Watutantrige *et al* (2012) reported of a significant difference (p= 0.023) when hand washing with soap was compared with without soup among medical students in Malaysia. Kitchen staff in Ghana were mostly not using soap for hand washing hence the high ACC count. This supports Owusu (2008) who reported that in Ghana less than 1 in 5 individuals wash their hands with soap at critical stages.

From Table 15, only 50% of kitchen staff were most likely to wash their hands before starting work. Coliforms ranged from 6.71 – 1.88 Log_{10} $CFUcm^{-2}$ with lowest category mean of 3.71 Log_{10} $CFUcm^{-2}$ from poor hygiene category schools followed by good hygiene schools. Medium hygiene category schools had the highest coliform mean (Table 21). The schools mean was 4.27±1.68 Log_{10} $CFUcm^{-2}$. High coliform count on staff hands could be due to faecal contamination as only 48% of the sampled kitchen staff reported that they most likely would wash their hands after visiting the toilet with 4.2% reporting they were unlikely to do so. Hence staff hands could serve as vehicles of cross contamination to cooked food. Kitchen staff characteristically did not wash hands with soap and hardly washed hands before food preparation. There was a notion that once staff bathed in the morning from home, their hands were clean. Kitchen staff needed training on effective hand washing. Forty five percent (45%) of the sampled schools had washing basins on toilets although soap was not readily available. Making available the needed resources and enforcing the practices of good hand washing was required. None of the schools met the 1 $Log_{10}CFUcm^{-2}$ advisory level for coliforms on food contact surfaces. This was unlike South Africa where Nhlapo *et al* (2014) had 60% satisfactory results in their schools and in Malaysia where schools had 71% satisfactory results (Tan *et al* 2013). Santana *et al* (2009) only reported on the presence of coliforms on staff hands in Brazil but stopped short on reporting levels. Hand hygiene required improvement to avoid the risk of food contamination.

Yeast and moulds on staff hands were lowest among the enumerated microorganisms with a Pre GHP range of 3.98 - 0.12 $Log_{10}CFUcm^{-2}$ and schools mean of 1.31±1.15 $Log_{10}CFUcm^{-2}$. Fifty five percent (55%) of the schools met the 1 $Log_{10}CFUcm^{-2}$ advisory level for yeast and mould on staff hands (Agriculture, Food and Rural Development of Manitoba, 2014).

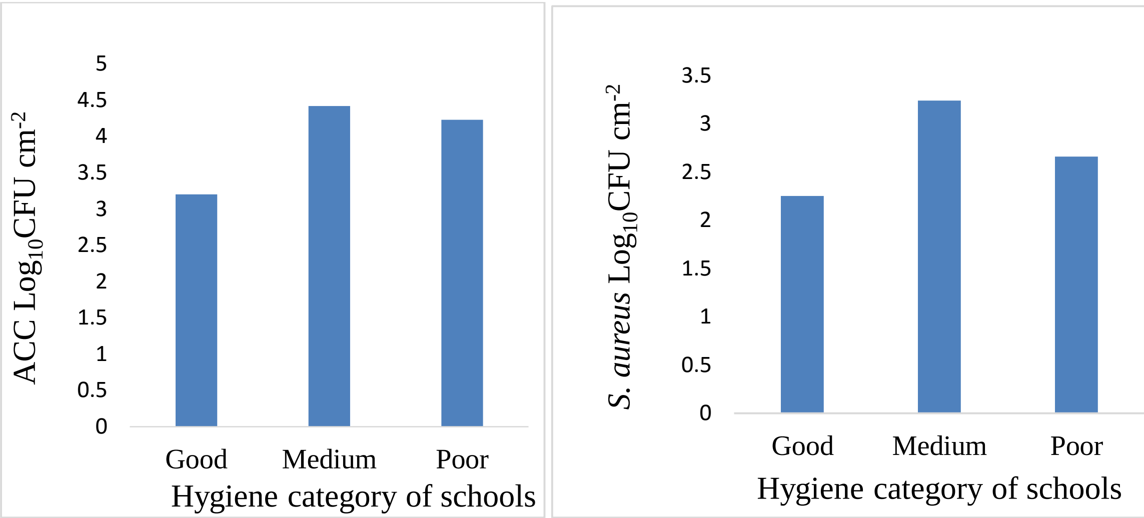


Fig 11. Microbiological contaminants on hands differ from checklist audit outcome

Raw grains and nuts used for meal preparation are sorted, picked and washed against physical, chemical and mould contaminantion by kitchen staff and these products without good post-harvest and storage practices could develop mould hence possible cross contamination from the kitchen environment (equipment, water, cleaning towels and aprons) after washing. These could be transferred into food which could affect deterioration of cooked food or produce toxins which could have both short and long term health consequence on consumers. High yeast and mould levels on staff hands could be from the air as kitchens were not properly enclosed (Nhlapo *et al* 2014) and dust with other contaminants including mould could deposit on items and staff hands. Nhlapo *et al* (2014) had 60% satisfactory yeast and mould levels on staff hands in South African schools, which was similar to the Ghanaian case. The other authors did not work on yeast and mould on food contact surfaces.

Staphylococcus aureus on staff hands ranged from 3.78 - 0.59 $Log_{10}CFUcm^{-2}$ with a schools mean of 2.73±1.08 $Log_{10}CFUcm^{-2}$. Good hygiene category had the least mean of 2.25 ± 1.42 and the highest mean was 3.24±0.61 $Log_{10}CFUcm^{-2}$ from medium hygiene category schools. Only one school met the 1 Log advisory standard for *S. aureus* (Sneed *et al* 2004, Santana *et al* 2009, Marzona and Balzeratti 2013) on food contact surfaces. Tan *et al* (2013) reported of a mean of 0.47±0.67 $Log_{10}CFUcm^{-2}$ on staff hands in Malaysian schools and Marzona and Balzeratti (2013) had 88.5% satisfactory *S. aureus* levels on staff hands (≤1 $Log_{10}CFUcm^{-2}$) in Italian schools. These schools highly met the advisory standard for *S. aureus* however they had HACCP in place with hand sanitizers usage as part of their cleaning procedure. Santana *et al* (2009) before GHP intervention reported of 4.38 $Log_{10}CFUcm^{-2}$ of *S. aureus* on staff hands in excellent hygiene schools in Brazil. This he added was higher than those in medium and poor hygiene category schools. On the contrary good hygiene schools in Ghana had the least category mean for *S. aureus* and none of the schools in Ghana reached 4 Log as recorded in Brazil for *S. aureus*.

4.3.3. ***Microbiological contaminants on food contact surfaces after current cleaning practices***

Inadequate cleaning and disinfection of food contact surfaces represent a risk factor for contamination (Rodriguez-Caturla *et al* (2012). Mensah *et al* (2002) reiterated that the use of soap to wash crockery reduced bacteria load in Accra, Ghana. Cleaning effectiveness of food contact surfaces including serving pans and ladles, kitchen knives and vegetable grinding machine (disc attrition mill) were evaluated microbiologically before GHP intervention. The cleaning of utensils and other food contact surfaces in the various kitchens were similar in all the schools though not standardised. The general procedure included rinsing of food waste after which a washing basin with a pool of water and detergent was used for washing. This followed by rinsing in another pool of clean water in a second basin. Water was not heated in any of the schools visited. Cooking was done either on fire wook or wood shavings (63.6%), gas cookers (9.1%) or both (27.3%).

Table 22. Microbiological contaminants on food contact surfaces Pre GHP intervention

		Microbial Count ($\log_{10}$ CFU cm^{-2})											
		ACC				Coliforms				Fungi			
Hygiene category	**School code**	**Pan**	**Ladles**	**Knives**	**Grinders**	**Pan**	**Ladles**	**Knives**	**Grinders**	**Pan**	**Ladles**	**Knives**	**Grinders**
Advisory guideline				**1.3**			**1.0**				**1.0**		
Good	OO7	4.08	5.17	6.64	5.11	1.86	6.60	6.64	3.72	1.63	1.64	3.49	3.98
	O10	3.04	6.60	6.60	4.49	2.31	6.60	6.60	3.99	1.15	1.28	1.08	2.75
	O19	2.97	3.11	1.82	4.72	4.19	2.32	3.96	4.54	2.68	2.48	1.49	4.09
	O26	3.33	5.13	4.30	3.61	2.48	5.53	4.40	3.44	4.02	3.23	3.36	2.28
Mean		3.36 ±0.51	5.00 ±1.43	4.84 ±2.29	4.48 ±0.64	2.71 ±1.02	5.26 ±2.03	5.41 ±1.42	3.92 ±0.34	2.37 ±1.27	2.16 ±0.87	2.35 ±1.25	3.20 ±0.8
Medium	OO2	3.85	5.16	5.23	5.72	2.85	4.66	4.71	3.43	3.82	3.54	2.63	4.98
	OO3	6.42	6.48	7.60	5.38	7.60	7.60	7.60	5.34	2.06	4.00	3.75	2.35
	OO5	6.60	6.60	6.60	N/A	5.58	6.60	6.61	N/A	2.54	3.27	2.29	N/A
	O12	6.60	6.60	6.60	6.90	6.60	6.60	3.62	6.90	1.36	3.72	3.65	2.96
Mean		5.87 ±1.35	6.21 ±0.70	6.51 ±0.97	6.10 ±0.80	5.66 ±2.05	6.37 ±1.23	5.63 ±1.80	5.22 ±1.74	2.45 ±1.04	3.63 ±0.31	3.08 ±0.73	3.43 ±1.78
Poor	OO1	3.47	3.16	2.01	6.60	6.60	3.60	6.60	6.60	2.11	0.90	3.28	4.02
	OO4	3.74	4.58	4.73	4.51	3.54	5.60	5.12	6.60	1.04	1.83	3.13	3.34
	O20	3.05	2.96	4.29	4.61	3.31	1.00	3.10	4.60	2.19	1.34	3.03	3.62
Mean		3.42 ±0.35	3.57 ±0.88	3.68 ±1.46	5.24 ±1.18	4.48 ±1.84	3.40 ±2.31	4.94 ±1.76	5.94 ±1.15	1.78 ±0.64	1.36± 0.46	3.15 ±0.12	3.66 ±0.34
Grand mean		4.29 ±1.49	5.05 ±1.46	5.13 ±1.93	5.16 ±1.01	4.26 ±2.00	5.16 ±2.06	5.36 ±1.51	4.92 ±1.36	2.23 ±0.99	2.48 ±1.12	2.83 ±0.88	3.44 ±0.86

NA- grinder not available

None of the schools had boilers hence hot water was not readily available in the kitchens for cleaning purposes. The ACC on food contact surfaces after cleaning varied considerably with a range from 1.88-7.60 Log10CFUcm-2 (Table 22). Both extremes were found on kitchen knives but from two different schools, OO3 from medium hygiene category schools and O19 of the good hygiene category schools respectively. With ladles, medium hygiene category schools had the highest ACC count of 6.21±0.70. Medium hygiene category schools had the highest category mean for ACC on pans at 5.87±1.35 $Log_{10}CFUcm^{-2}$, poor hygiene category schools had 3.42±0.35 Log_{10} CFU cm^{-2}. Good hygiene category schools had 3.36± 0.51 $LogCFUcm^{-2}$ followed by poor hygiene category schools with 3.57±0.88. ACC on knives among the categories were also highest in medium hygiene schools with 6.13±0.66, good hygiene schools had 4.84±0.62 followed by poor hygiene schools with 3.68±1.46. Medium hygiene category schools also had the highest ACC for grinders after cleaning with a mean of 6.13±0.66 $Log_{10}CFUcm^{-2}$, followed by poor hygiene schools with 5.24±1.18 Log_{10} $CFUcm^{-2}$. Good hygiene schools recorded a mean of 4.41±0.62 $Log_{10}CFUcm^{-2}$ on grinders. Only ACC on knives from school O19 (1.81 Log) came close in conformity with the advisory standard of 1.3 Log_{10} $CFUcm^{-2}$ for ACC as used by Sneed *et al* (2004), Santana *et al* (2009) and Marzano and Balzaretti (2013). The microbiological contaminats on the food contact surfaces did not follow the initial audit outcome as although good schools had lower ACC counts on all samples with the exception of grinders, medium schools in this case recorded higher ACC values than poor schools on all the equipment. Santana *et al* (2009) before their GMP intervention in schools in Brazil recorded ACC on plates, serving spoons and ladles within a range of >7.0 – 3.5 Log_{10}CFU cm^{-2}. Ladles in Excellent hygiene category schools had >5Log_{10} CFU cm^{-2}, those in medium hygiene category schools had 4 log and those in poor hygiene category schools had >6 Log_{10} CFU cm^{-2}. Thus microbiological contamination on surfaces did not necessarily follow the pre GHP hygiene audit categorisation as in this case. Marzona and Balzaretti (2013) studied cleaning in Italian schools and reported that 98.6% of 139 samples met the above advisory standard of 1.3 Log_{10} $CFUcm^{-2}$ after regular cleaning practices. These schools however had HACCP in place and included sanitisers in cleaning procedure which was not available in the Ghanaian case. Sneed *et al* (2004) on the other hand reported of ACC range of 1.0 - 3.90 Log_{10} $CFUcm^{-2}$ on mixing bowls and 1.0 - 4.70 $Log_{10}CFUcm^{-2}$ on cutting boards. In her case only 27.5% of cutting boards and 30.0% of mixing bowls conformed to the advisory standard of 1.3 Log_{10} $CFUcm^{-2}$ even with the use of dishwasher for sanitizing. The higher end in Sneed *et al* (2004) report was also lower than what was found in the Ghanaian schools. Nhlapo *et al* (2014) on their work on cleanliness of food contact surfaces in South African schools had 80% unsatisfactory results and in this report there were 100% unsatisfactory result for ACC count.

The range of coliforms on cleaned food contact surfaces was 1.00 - 7.60 $Log_{10}CFUcm^{-2}$. The highest load of 7.60 $Log_{10}CFUcm^{-2}$ was found on pans, ladles and knives all from school OO3 in a medium hygiene category school. High coliform loads on food contact surfaces especially serving pans and ladles which came into contact with ready to eat (RTE) cooked meals meant they were significant potential vehicles of pathogens (Nhlapo *et al* , 2014). A coliform load of 1.0 Log_{10} $CFUcm^{-2}$ was found on ladles in school O20 from a poor hygiene category school. Poor hygiene category schools coliforms on utensils ranged from 1.00 - 6.60 Log, medium hygiene schools had 2.85-7.60 $Log_{10}CFUcm^{-2}$ and good hygiene category had a range of 1.86 - 6.60 $Log_{10}CFUcm^{-2}$. Pans and knives had the highest coliform count after cleaning with ranges of 1.86 – 7.60 and 3.10 - 7.60 $Log_{10}CFUcm^{-2}$ respectively. Ladles recorded the lowest coliform count of 1 Log_{10} which was in conformity to the advisory standard of 1.0 Log_{10} CFU cm^{-2} for coliforms on cleaned surfaces used by Sneed *et al* (2004), Santana *et al* (2009) and Marzano and Balzaretti (2013), but also had a higher level of 6.60 $Log_{10}CFUcm^{-2}$. The coliform load on grinders ranged from 3.43 to 6.60 log_{10} $CFUcm^{-2}$. Thus only 2.3% of sampled items conformed to the advisory standard in the Ghanaian schools after regular cleaning before GHP intervention whilst Nhlapo *et al* (2014) reported of 40% satisfactory results in South African schools. Unlike Santana *et al* (2009) who did not investigate coliforms on utensils after cleaning in Brazil, Marzano and Balzaretti (2013) reported of 98.3% of 139 sampled food contact surfaces from Italian schools conforming to the advisory guideline of 1.0 Log_{10} CFU cm^{-2} after regular cleaning procedure including sanitizing. Sneed *et al* (2004) also reported of 85% conformity to advisory guideline with the 40 sampled kitchen tools investigated in Iowa in the US. Coliforms in the Ghanaian case were thus higher than those conducted in South Africa, Italy and the US. Addo *et al* (2007) on their work in hotels in Accra-Ghana, reported that 22% of plates, 50% of knives , 50% of fruit dispensers, 54% of cutting boards and 75% of pastry tables carried coliforms after cleaning. They reported on the presence of coliforms on equipment after cleaning but did not report of bacteria load or count on these equipment. From this SHSs cleaning report (Table 22) in the Ashanti Region of Ghana, all the equipment sampled had coliforms present.

The range of yeast and moulds on food contact surfaces after current cleaning practices was 0.90 – 4.98 Log_{10} $CFUcm^{-2}$. These were from ladles in school OO1 from a poor hygiene category school and a grinder from school OO2 in a medium hygiene category school respectively. The yeast and mould range in poor hygiene schools was 0.90 – 4.02, medium hygiene schools was 1.36-4.98 and the good hygiene categories had 1.08 – 4.08 Log_{10} CFU cm^{-2}. Neither Sneed *et al* (2004), Santana *et al* (2009) nor Marzano and Balzaretti (2013), investigated yeast and moulds on food contact surfaces in their work in school kitchens. Mensah *et al* (2002) and Addo *et al* (2007) who worked in commercial catering in Ghana equally did not investigate on yeast and moulds on food contact surfaces. Serving ladles in OO1 alone (9.1%) met the 1 Log_{10} CFU cm^{-2} for yeast and mould after cleaning guidelines of the Agriculture, Food and Rural Development (2014) in Manitoba. Nhlapo *et al* (2014) reported of 40% satisfactory results for food contact surfaces in South African schools. This was higher than the report in the Ghanaian case where 2.3% was satisfactory. The presence of yeast and moulds on food contact surfaces in this study could be due to lack of properly controlled storage area for equipment after cleaning, unclean sponges used for cleaning which some staff habitually kept on the floor, which were not also air dried after work, poor maintained tables and shelves on which utensils, knives and ladles were kept and from stored cereals and grains in the kitchen and air contamination which could be controlled with GHP.

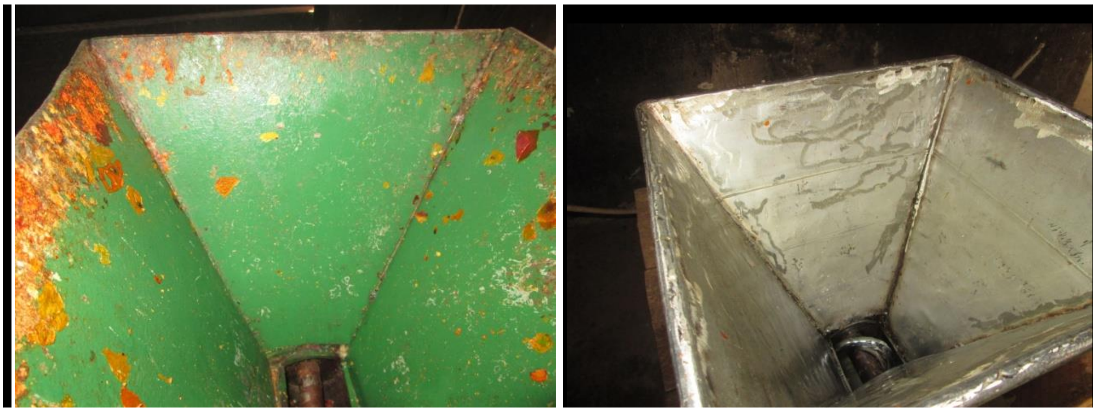


Plate 21 and 22. Disc attrition mill (grinding machine) quality and maintenance in a Poor Hygiene category school (Left) and Medium Hygiene category school (Right)

Seventy percent (70.0%) of the grinders were used to mill vegetables for uncooked RTE sauces for the schools. Thirty percent were used for grinding maize for ‘kenkey’ and ‘banku’. Although the rest of the schools had vegetable grinding machines they were broken down and had not been repaired, hence schools depended on public services which lacked control. Such public services for grinding vegetables was equally a risk. It was also realised that only 1 out of the 10 of the grinders was made out of stainless steel material which brought rust and other chemical contamination including paint (Plate 21, 22) into food. The high level of bacteria from poorly cleaned equipment (Plate 21) added to the micro flora on raw vegetables when poorly cleaned could be a risk to consumers. Cleaning practices in the sampled schools and across categories required interventions to avoid the eminent case of food poisoning on large scale in the schools. Matron’s supervision needed to by holistic, focusing equivalent attention on staff supervision and cleaning as current responsibilities evidently focused on production leaving the quality control aspect of food safety. High microbial levels of food contact surfaces was a risk to students as cooked food came into contact with pans and ladles, staff hands was also poorly cleaned which was also a food safety risk.

4.3.4. *Summary*

The current hygiene practices and effect on incidence of foodborne pathogens in Senior Secondary School kitchens in Ashanti Region was analysed in hygiene categorised schools. Eight of the schools (17.8%) were categorised as good hygiene schools, thirty three (73.3%) were medium and 4 (8.9%) were poor hygiene categorised of the 45 schools sampled. Poor hygiene category schools had the least scores in facility design, equipment and utensils maintenance. Control of access to kitchens by unauthorised persons was least in poor hygiene category schools. Pest control and cleaning were substandard in all categories. None of the hygiene categories had hot holding equipment or temperature monitoring device although good hygiene category schools recorded an acceptable temperature (>63℃) for cooked jollof with the least food holding time before meals. Eleven (11) schools, 4 good, 4 medium and 3 poor hygiene schools were sampled for cooked food and food contact surface microbiological contaminants assessment. Whilst microbiological contaminants in food and food contact surfaces were predominantly lower in good hygiene category schools, medium hygiene category schools had the highest for most enumerated contaminants than poor hygiene schools although none of the categories met the acceptable criteria for microbiological contaminants set by the Ghana standards authority (GS955, 2013). Lack of standardised hygiene practices in the schools required improvement which was evident in the unsatisfactory levels of microbiological contaminants in sampled jollof rice, staff hands after washing and food contact surfaces. Groundnut soup was comparatively safer as food holding temperature and time and microbiological contaminants were within the acceptable national limits with *Salmonella* not detected. *B. cereus* on the other hand could be a potential food poisoning bacteria in cooked rice in the schools requiring raw material and processing control. The process control of jollof rice, holding temperature and time, availability of hand washing facilities and consumables and training of staff on GHP with emphasis on infectious disease control, standard cleaning procedure and hand washing regime with improved supervision were required.

4.4 Effect of Good Hygiene Practices training intervention on staff hygiene practices and food safety and quality in SHS's in Ashanti Region of Ghana

This study evaluated the effect of GHP training as an intervention on the kitchen staff food and personal hygiene knowledge scores, their hygiene behaviour including hand washing, temperature and time control of cooked food. The microbiological contaminants in food and on food contact surfaces after cleaning were also investigated after GHP intervention (Refer to Section 3.5).

4.4.1 *Effect of Food Hygiene training on staff Food Hygiene Knowledge (FHK) and Personal Hygiene Requirement (PHR) scores*.

Table 23. Pre and Post GHP training staff food and personal hygiene knowledge scores

Category	Code	PreFHKscores%	PostFHKscores%	PrePHRscores%	PostPHRscores%
Good	OO7	28.0	73.0	72.3	84.0
	O10	44.7	66.5	74.0	91.5
	O19	31.3	78.0	69.0	81.5
	O26	23.3	76.0	59.5	88.3
Category mean		31.8±9.2.	73.4±5.0	68.6±6.5	86.3±4.4
Medium	OO2	38.0	78.0	77.8	83.3
	OO3	49.5	76.5	89.0	85.0
	OO5	24.8	89.8	68.8	81.3
	O12	31.4	59.5	67.3	78.0
Category mean		35.9±10.8	75.9±12.5	75.7±10.1	81.9±3.0
Poor	OO1	42.8	74.8	67.5	83.0
	OO4	34.5	98.3	60.8	73.8
	O20	36.5	80.3	61.0	74.3
Category mean		37.9 ±4.3	84.4± 12.3	63.1± 3.8	77.0±5.2
Schools Mean		34.9±8.3	77.3±10.3	69.7± 8.6	82.2±5.4

FHK- Food Hygiene Knowledge, PHR- Personal Hygiene Requirement

Food hygiene knowledge scores increased substantially across the categories with percentage mean difference of more than 40% in each category of schools clearly indicating that knowledge acquisition had taken place as all the schools failed (<50%) in the initial test (Table 23 and Figure. 12). Personal Hygiene knowledge scores also improved after training (Fig 12) with 13.9%, 10.8% and 28.8% mean score increase for poor, medium and good hygiene category schools. This supports Sneed and Henroid (2007) and Santana *et al* (2012) who reported a positive effect of training on employee studied in US and Brazil respectively.

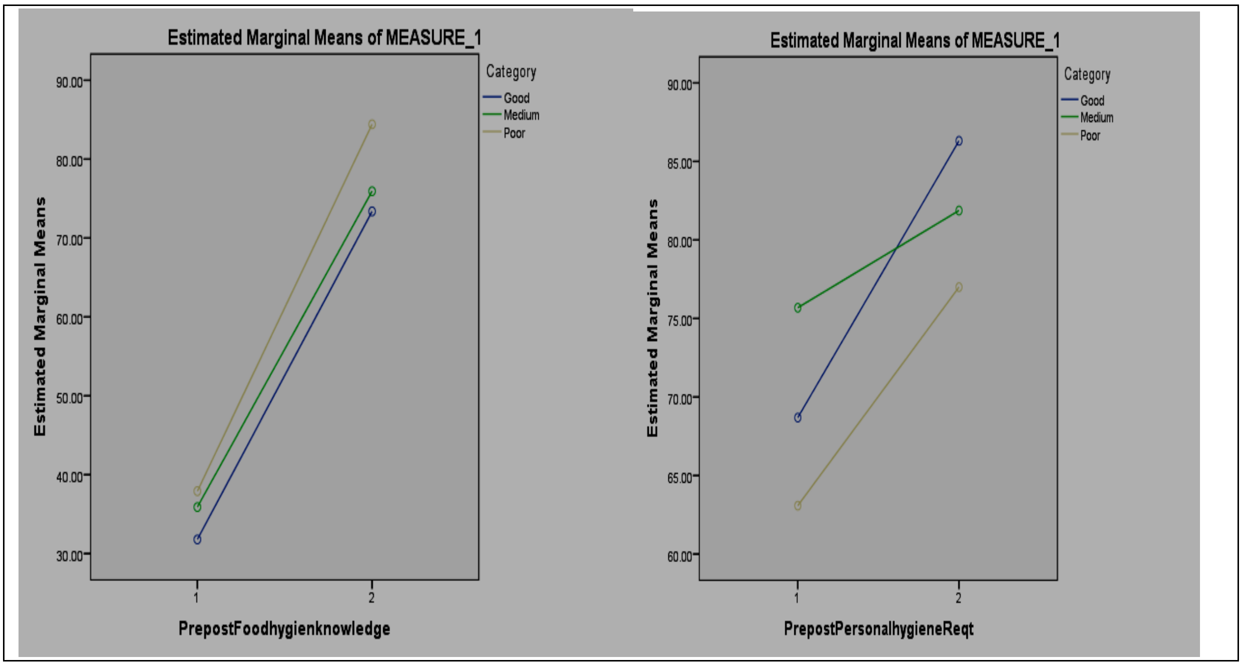


Fig. 12. Effect of GHP intervention on kitchen staff food hygiene awareness and personal hygiene requirement scores

Sneed and Henroid (2007) in their study on the impact of educational interventions on the implementation of HACCP in US reported that food safety knowledge of the sampled staff was high for both Pre and post test ($67.6 \pm 14.4 – 87.0 \pm 9.7$, p=0.001). On the contrary the staff in the current study in Ghana had low FHK scores before the training. This could be due to the absence of previous training as 90.6% of staff in these schools reported not to have had any GHP training (Table 13) at their work place. There was a statistical significant difference between Pre and Post FHK and PHR scores (Table 24) using Wilcoxon's signed-rank test. Santana *et al* (2009) who used a visual inspection check list, equally reported of better scores with poor and medium hygiene category schools classified as good hygiene category schools and the excellent hygiene category school score also increasing after GHP adoption.

Table 24 Wilcoxon signed-rank test on staff Food Hygiene and Personal Hygiene Requirement knowledge after GHP intervention ($p \leq 0.05$)

Variable	N	Z	p(1-tailed)
Pre- post FHK	11	-2.934	0.001
Pre- post PHR	11	-2.847	0.001

4.4.2 Effect of GHP training on cooked food (jollof rice) temperature and food waiting time

The mean temperature for jollof before GHP training was below 63 ℃ with the exception of good category schools which had a mean temperature of 65 ℃ with a mean holding time of 46 minutes ±14.99 (Table 24). The longest PreGHP food holding time after service was 120 minutes. After GHP intervention all hygiene categories increased food temperatures at service above the 63 ℃ with time also falling within the 60 minutes proposed. Medium hygiene category schools improved with mean temperature difference of 10 ℃ and a mean reduction time difference of 35 minutes. Good hygiene and poor hygiene category schools equally increased the temperature of food with slight reductions in food waiting time (Fig.13). School O20 recorded longer waiting time than before GHP intervention (Table 25). This was because the matron was absent during this weekend and staff practice in the absence of a matron was to hurry with their chores and leave for their various homes. Indicating that in the absence of supervision, what personnel have learnt might not be put into use. This thus necessitate the presence of hygiene trained chief cooks or assistant matrons to take up monitoring and supervision in the absence of the manager. Food temperature could drop to unsafe levels whilst waiting for students' meal time. School O19 increased food waiting time but was still within the proposed 60 minutes during training. The general increase in mean food temperature and reduced mean waiting time of cooked food from 60.4 ℃ to 69 ℃ and 58 to 43.5 minutes (Fig. 13) indicated a change.

Table 25. Effect of GHP intervention on cooked food temperature and food waiting time

Hygiene Category	School code	Pre training food temp. (℃)	Pre training Food waiting time (min)	Post training Food Temp(℃)	Post training Food waiting time(min)
Good	OO7	69.5	36.5	66.0	55.0
	O10	59.5	57.5	77.5	45.0
	O19	61.5	60.0	60.0	55.0
	O26	68.5	30.0	77.0	20.0
Category mean		64.75± 4.99	46.00±14.99	71.38±6.81	43.75±16.52
Medium	OO2	49.5	35.0	73.0	25.5
	OO3	65.0	120.0	66.0	25.0
	OO5	54.5	35.0	61.0	30.0
	O12	57.5	75.0	66.5	45.0
Category mean		56.68±6.51	66.25±40.49	66.63±4.92	31.38±9.36
Poor	OO1	68.0	100.0	69.5	45.0
	OO4	55.0	60.0	61.0	35.0
	O20	55.5	27.5	73.5	97.5
Category mean		59.50±7.37	62.50±36.31	68.00±6.38	59.12±33.57
Schools mean		60.36±6.66	57.86±30.23	68.73±5.83	43.45±21.59

Acceptable temperature for hot holding meals was given as 63^{O}C (FSA, 2013) during training, and time for food to be cooked and ready and time to serve as 60min to meal time respectively.

This change in temperature control was significantly different ($p<0.05$) although Post GHP food holding time was not significantly different from Pre GHP time (Table 26). Balzaretti *et al* (2009) reported of non-conformances reducing from 55% to 30% in a year through progressive temperature and time management after training. A significant improvement in temperature control in this report in the schools could equally positively affect food safety. Santana *et al* (2009) in Brazil reported an increase in cooking and serving temperature after training for all categories with the exception of poor hygiene category which had a serving temperature of 46 ℃ ± 1.6 from 40 ℃ ±1.7 minutes.

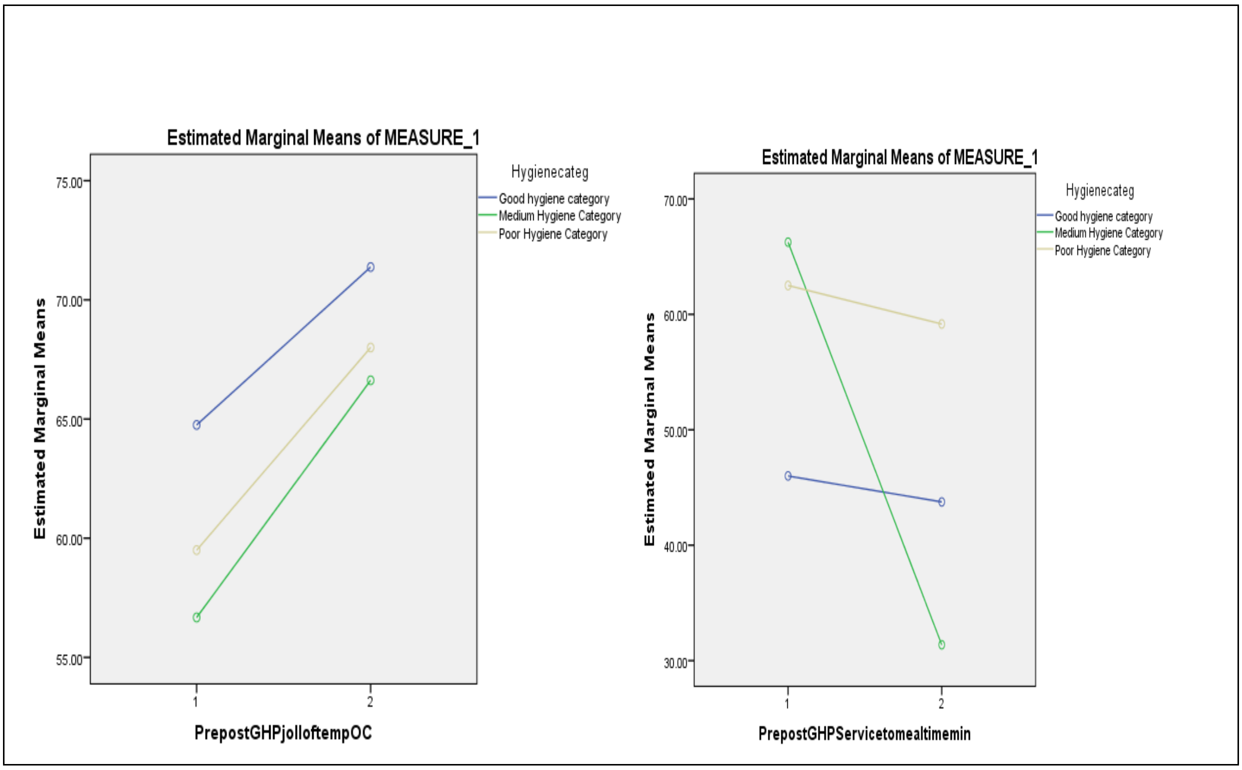


Fig.13 Effect of GHP intervention on food temperature and time control across hygiene categories

The good category school in Brazil also had hot holding equipment for cooked ready to eat meals. From this current research none of the 45 schools from Ashanti Region had hot holding equipment for cooked food. Provision of hot holding equipment could be useful in the schools.

Table 26 Wilcoxon signed-rank test on food holding temperature and time Post GHP

Variables	N	Z	p (1- tailed)
Pre-Post food temp.(^{O}C)	11	-2.625	0.003
Pre-Post food waiting time (Min)	11	-1.512	0.070

Though jollof rice is processed at high temperature that should kill vegetative cells (>80°C) it could be cross contaminated from serving equipment and food handlers in a poor hygiene environment (Mensah *et al* 2002). Survival and regeneration of spores are also possible as after cooking temperatures are allowed to fall in an uncontrolled environment for longer periods before meals. Hence high temperatures during cooking and service are essential to avoid growth and survival of microorganisms present. Time control still required improvement after GHP intervention.

4.4.3. Effect of GHP training on the microbiological quality of food (jollof rice)

Table 27. Effect of GHP intervention on microbiological quality of Jollof/Rice meals

				Microbiological data in $Log_{10}CFUg^{-1}$							
Hygiene Category	**Sch-ool code**	**Pre GHP ACC**	**Post GHP ACC**	**Pre GHP Coli-forms**	**Post GHP Coli-forms**	**Pre GHP Yeast and moulds**	**Post GHP Yeast and moulds**	**Pre GHP *S. aureus***	**Post GHP *S. aureus***	**Pre *B. cereus***	**Post *B. cereus***
Acceptable levels (GSS:955)		4		2		3		2		2	
Good	OO7	5.24	3.02	5.15	4.00	2.65	3.31	3.94	2.00	2.30	3.18
	O10	2.99	4.00	2.99	2.65	2.27	<2.00	2.15	2.00	2.27	2.33
	O19	3.00	3.45	2.59	2.50	4.10	<2.00	2.77	2.24	2.86	2.00
	O26	3.92	3.04	3.31	2.41	3.47	2.15	<2.00	2.00	2.78	2.00
Category mean		3.74 ±1.06	3.38 ±0.46	3.51 ±1.13	2.89 ±0.75	3.12 ±0.82	2.36 ±0.63	2.71 ±0.88	2.06 ±0.12	2.55 ±0.31	2.38 ±0.56
Medium	OO2	4.19	3.44	3.35	3.14	3.83	2.09	3.80	2.00	3.15	4.52
	OO3	5.81	2.65	3.07	<2.00	2.65	2.15	4.12	2.00	3.47	3.54
	OO5	3.69	2.69	2.52	3.04	2.91	<2.00	2.54	2.00	2.96	3.78
	O12	5.30	3.26	4.52	2.66	2.15	3.40	3.82	2.00	4.15	2.15
Category mean		4.75 ±0.97	3.01 ±0.40	3.37 ±0.84	2.71± 0.52	2.89 ±0.70	2.41 ±0.66	3.57 ±0.71	2.00 ±0.00	3.43 ±0.52	3.49 ±0.99
Poor	OO1	6.60	2.24	6.03	2.22	3.74	2.72	4.31	2.00	5.11	2.00
	OO4	5.75	3.63	2.80	2.74	<2.00	2.43	5.22	2.65	3.65	2.50
	O20	3.09	4.04	2.50	3.62	3.00	<2.00	3.22	2.50	3.50	3.91
Category mean		5.15 ±1.83	3.30 ±0.94	3.78 ±1.95	2.86 ±0.70	2.91 ±0.87	2.38 ±0.36	4.25 ±1.00	2.38 ±0.34	4.09 ±0.89	2.80 ±0.99
Schools mean		4.51 ±1.28	3.23 ±0.57	3.53 ±1.18	2.82 ±0.59	2.98 ±0.72	2.39 ±0.53	3.44 ±0.99	2.13 ±0.24	3.29 ±0.83	2.90 ±0.92

Hygiene Category – Post ACC (p=0.021), Hygiene category-Post Coliforms (p=0.022), Hygiene category – *Bacillus cereus* (p=0.021)

After GHP training cooked food mean microbial load in the schools reduced for all the organisms enumerated (Table 27). The national acceptable level of ACC in cooked food from the Ghana Standards Authority's GS 955:2013 was 4 Log_{10} CFU g^{-1}. After GHP intervention only school O20 from poor category exceeded this, but was only slightly above (0.04 Log_{10} $CFUg^{-1}$). The rest of the schools had Post GHP ACC load ranging from 2.24 – 4 Log_{10} CFU g^{-1} and a mean schools ACC of 3.23±0.57 $Log_{10}CFUg^{-1}$ from Pre GHP record of 4.51 ±1.28 Log_{10} CFU g^{-1}. The Post GHP schools mean for ACC was higher than the 2.99 ± 2.29 in cooked rice reported by Mensah *et al* (2002) in Accra but less than the 5.48±0.97 Log_{10} CFU g^{-1} in macaroni sold in Kumasi of the Ashanti Region of Ghana (Feglo and Sakyi, 2012). The result was similar to 4 Log_{10} CFU g^{-1} reported by Adolf and Azis (2012) in rice meals from schools in Indonesia. Santana *et al* (2012) recorded Log reduction of 3.5, 0.2 and 0.5 for poor, medium and good hygiene schools meals respectively as a result of GHP training. Schools from the Ashanti Region of Ghana in this study recorded 1.85, 1.74 and 0.36 Log reductions for poor, medium and good hygiene category schools respectively. This work thus supports Sneed and Henroid, (2007), Hwang *et al* 2001 and Santana *et al* (2012) that food quality is improved with increased food hygiene knowledge. There was a significantly negative correlation between Pre and Post GHP ACC count in jollof rice, Spearman's r= -0.636 (p=0.035) (Table 28). The acceptable level of total coliforms in cooked food set by GS 955:2013 of Ghana Standards Authority (2013) was 2 $Log_{10}CFUg^{-1}$. One school (OO3) met this national acceptable level in cooked rice meals. This was the only school where the matron ensured that staff in charge of washing utensils heated the water during both announced and unannounced visits after the GHP training by the researcher. The overall schools mean (3.23±0.57 $Log_{10}CFUg^{-1}$) was above the national acceptable level although there was a mean reduction of 0.71 Log_{10} CFU g^{-1} from Pre GHP level. Total coliform count in jollof rice Post GHP was higher than the 1.5 ±2.04 Log_{10} $CFUg^{-1}$ in rice sold by food vendors in Accra-Ghana reported by Mensah *et al* (2002).

Schools O12 and OO7 were the only schools with Post GHP yeast and mould levels > 3 Log_{10} CFU g^{-1}. All the hygiene categories had mean yeast and mould levels within the national acceptable level of 3 $Log_{10}CFUg^{-1}$ (GS 955, 2013) in ready to eat food. Current Yeast and mould levels were similar to the 3 $Log_{10}CFUg^{-1}$ reported by Adolf and Azis (2012) from school meals in Indonesia. Further reduction in schools O12 and OO7 could help prevent the long term exposure effects of mycotoxin to the health of the consumer.

All the schools had mean reduction in *Staphylococcus aureus* count after GHP intervention with the exception of school O26 which maintained the 2 $Log_{10}CFUg^{-1}$ which was however the national acceptable level of *S. aureus* in cooked rice. Eight schools (73%) met the acceptable level of 2 $Log_{10}CFUg^{-1}$ Post GHP intervention. There were no coagulase positive *Staphylococcus aureus* identified in jollof rice across the schools after GHP intervention. Post GHP *Staphylococcus aureus* load, in all the good and medium hygiene category schools met the acceptable level of 2 $Log_{10}CFUg^{-1}$ set by GS 955:2013, with the exception of school 019 which had 2.24 $Log_{10}CFUg^{-1}$. Schools in poor hygiene category recorded a mean level of 2.38 ± 0.34$Log_{10}CFUg^{-1}$. Three schools out of this category had *Staphylococci* levels > 2 Log_{10} < 3$Log_{10}CFUg^{-1}$.

Table 28. Spearman's correlation (R) Test for Jollof Rice

	Post GHP food holding time	**Post GHP ACC**	**Post GHP *Bacillus cereus***
Post GHP food holding time		0.56(0.06)	
Post GHP Coliforms	0.45 (0.16)	0.41 (0.21)	0.63(0.04*)
Post GHP *S. aureus*		0.65(0.03*)	

p≤0.05

Adolf and Azis (2012) reported of 3.39 $Log_{10}CFUg^{-1}$ of *Staphylococcus aureus* in rice in Indonesia school meals which was higher than the current results from Ghana Post GHP, but similar to Santana *et al* (2009) who reported absence of coagulase positive *Staphylococcus aureus* in meals in Brazil after training from all the three hygiene category schools. Overall schools *Bacillus cereus* in jollof rice reduced from 3.29 ± 0.83 to 2.90± 0.92 with a mean difference of 0.39 $LogCFUg^{-1}$. Both good and poor hygiene category schools reduced their Pre GHP *Bacillus cereus* levels by 0.17 and 1.29. Medium hygiene category schools did not reduce but had a slight increase of 0.06 $LogCFUg^{-1}$.

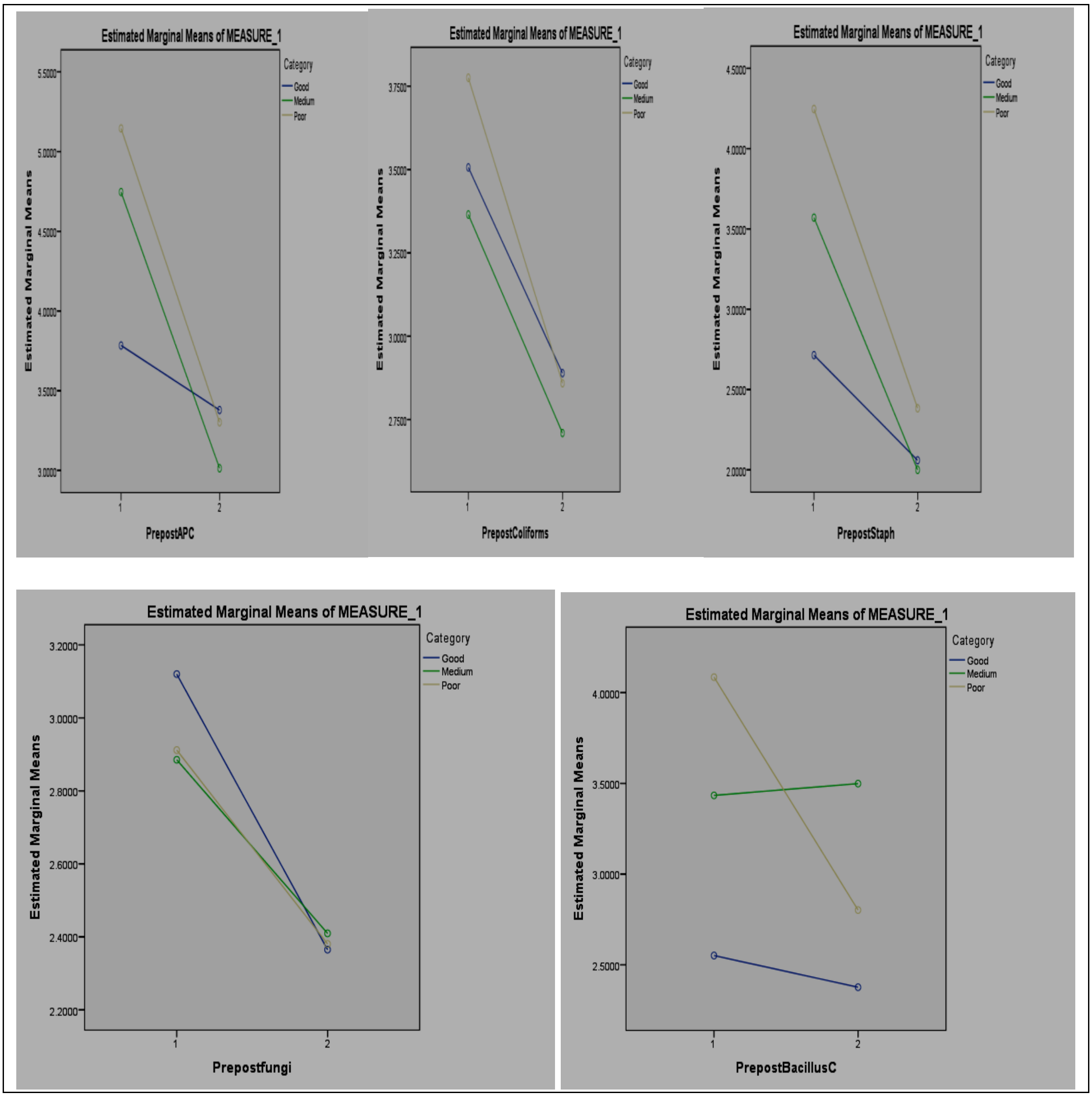


Fig 14. Effect of GHP intervention on jollof rice microbiological quality across hygiene categories

With schools Post GHP mean *Bacillus cereus* load of 2.90 ±0.92 $Log_{10}CFUg^{-1}$, and only one school from poor category and two from Good hygiene category falling within the acceptable national level of 2Log_{10} CFU g^{-1} (GS 955:2013) for cooked meals, *Bacillus cereus* levels generally was still high although not to toxin producing levels ($>10^5$) that could cause food poisoning (Blackburn and McClure, 2009). *Bacillus cereus* is not a personal hygiene issue but related to the raw material delivered to the kitchens. It is also an indicator of inadequate processing and food holding tempeatrues allowing spores germination after thermal treatment. Hence supplier and raw material control with microbiological specification could help improve on the levels of *B. cereus* in jollof rice. Temperature and time abused food notably causes food poisoning in the presence of pathogenic bacteria and with school OO2, a high level of 4.52 Log_{10} $CFUg^{-1}$ *B. cereus* could be a food risk. Adolf and Azis (2012) reported that the safety levels of food served at three different schools did not depend on their different socio economic backgrounds in Indonesia but on sanitation practices. In this study, an introduction of GHP in the kitchen, hence change in sanitation practices improved safety of food (Fig. 14) through overall reduction of microbiological load. There was a moderately positive correlation between Post GHP food holding time and ACC load in jollof rice, although not significant r = 0.56 (0.06). Thus the longer food was cooked in advance to meal time the higher was the ACC load in jollof rice. There was an equally weak but positive correlation between Post GHP total coliforms load in jollof rice and Post GHP food holding time this was also not significant at $p<0.05$ (Table 28). However longer waiting times under favourable conditions, high nutrient, suitable temperature, available moisture and high pH have always been a risk where food safety is concerned. These factors make jollof rice a high risk food. There was a statistically significant positive correlation between Post GHP coagulase negative *Staphylococcus aureus* in jollof rice and Post GHP ACC (Table 29). Level of Post GHP *Bacillus cereus* also significantly and positively correlated with Post GHP total coliforms load in jollof rice.

Wilcoxon's signed rank-test for non-parametric repeated measure was used to investigate the effect of GHP intervention on Pre GHP data (Table 29).

Table 29. Wilcoxon's signed-rank test on jollof rice microbial quality Post GHP

Variables	N	Z	p (1- tailed)
Pre- post GHP ACC Jollof	11	-1.956	0.027*
Pre- post GHP Coliforms	11	-1.778	0.042*
Pre- post GHP Yeast and moulds	11	-1.689	0.051
Pre- post GHP *Staph. spp*	11	-2.803	0.001*
Pre- post GHP *Bacillus cereus*	11	-0.533	0.319

P<0.05

With the exception of medium hygiene category schools where *Bacillus cereus* load did not reduce at Post GHP intervention (3.43 ± 0.52 to 3.49 ±0.99 $Log_{10}CFUg^{-1}$) but increased slightly all the other microorganisms enumerated reduced (Fig 14) with significant difference in ACC, *S. aureus and* total coliforms counts from Pre GHP intervention levels (Table 28). Post GHP ACC, *S. aureus* and total coliforms were Z= -1.956, p = 0.027, Z= -1.778, p=0.042 and Z=-2.803, p=0.001 respectively from Pre GHP intervention levels (Table 29). The GHP intervention improved the microbiological quality and safety of jollof rice.

4.4.4 *Effect of GHP training intervention on Staff hand washing practices- (hygiene behavior)*

Plate 23. Both hands of staff being swabbed by researcher

During GHP training staff were taken through the 5 steps of effective hand washing (Plate 24-27) as proposed by WHO (2009).

The importance of the use of anti-bacteria soaps for effective hand washing was also given during training with the help of Pro-Clean test swabs from Hygiena International which gave colour change for poor hand washing (water only) and effective hand washing (water with anti-bacteria soap) (Section 3.5). Staff hands (washed) were swabbed during field visits (Plate 23) for microbiological analysis during food preparation.

Plate 24-27. Steps used in explaining effective hand washing with Pro-clean from Hygiena

There were reductions on ACC, coliforms, yeast and mould and *Staphylococcus aureus* levels Post GHP intervention on staff hands (Table 30). Post GHP ACC range was 4.74 - 1.65 $Log_{10}CFUcm^{-2}$ with a new school mean of 2.57± 0.88 from a Pre GHP mean of 3.92±1.28 Log10CFUcm^{-2}.

Table 30. Effect of GHP training on staff hand hygiene

		Microbiological data on hands in $Log_{10}CFUcm^{-2}$							
Hygiene Category	**School code**	**Pre ACC**	**Post ACC**	**Pre Coliform**	**Post Coliform**	**Pre Y&M**	**Post Y&M**	**Pre *S. aureus***	**Post *S. aureus***
Advisory guideline		1.3		1.0		1.0		1.0	
Good	O26	2.79	2.27	2.37	2.24	2.00	0.59	1.71	1.44
	O19	3.61	1.65	3.55	1.20	2.11	0.41	2.92	0.71
	O10	1.72	2.44	5.71	1.31	0.12	2.19	3.78	1.32
	OO7	4.71	2.76	5.91	3.68	0.59	2.42	0.59	3.71
Mean		3.20±1.26	2.30±0.47	4.33±1.66	2.11±1.15	1.21±1.00	1.41±1.05	2.25±1.42	1.79±1.31
Medium	O12	5.71	2.22	5.71	3.08	0.76	0.88	3.23	1.25
	OO5	2.91	2.27	2.51	1.01	0.76	1.08	2.40	0.38
	OO3	5.22	1.73	6.71	1.67	0.44	0.18	3.70	1.42
	OO2	3.86	4.74	3.59	4.00	3.98	1.49	3.63	4.73
Mean		4.42±1.27	2.74±1.35	4.62±1.92	2.44±1.35	1.48±1.67	0.91±0.55	3.24±0.61	1.94±1.91
Poor	O20	3.32	3.11	1.88	3.63	1.12	1.87	1.35	0.81
	OO4	3.66	3.16	3.54	1.45	0.30	0.33	3.61	1.24
	OO1	5.70	1.84	5.71	1.53	2.09	0.53	3.02	1.58
Mean		4.23±1.29	2.70±0.75	3.71±1.91	2.21±1.23	1.17±0.91	0.91±0.84	2.66±1.17	1.21±0.38
Schools mean		3.92±1.28	2.57±0.88	4.27±1.68	2.26±1.13	1.31±1.15	1.09±0.79	2.72±1.08	1.69±1.32

Y&M – Yeast and mould

Although the schools could not meet the 1.3 $Log_{10}CFUcm^{-2}$ advisory standard for cleaned food contact surfaces (Sneed *et al*, 2004, Santana *et al* 2009, Osimani *et al* 2011 and Marzona and

Balzeratti, 2013) there were log reductions of 0.90, 1.68 and 1.53 $Log_{10}CFUcm^{-2}$ across categories for good, medium and poor hygiene schools. There were however larger log reductions in the medium and excellent hygiene schools in Brazil as reported by Santana *et al* (2009) after GHP intervention. The Brazilian schools had 0.90, 3.2 and 4.5 Log reductions after the GHP intervention for poor, medium and excellent hygiene schools. These schools however incorporated hand sanitizing with the use of iodophor solution at 100 mgl^{-1} which was absent from the Ghanaian schools who predominantly used plain soap and water in hand washing. Anti-bacterial soaps were expensive as compared to plain soaps and hand sanitizers were not readily available on the Ghanaian market, hence even though knowledge was acquired it could not be put into practice. It was clear that economic status of the schools in Ghana affected their known hygiene practices even though Adolf and Azis (2012) reported otherwise for Indonesia. Hand washing with plain soap and water had been reported to be good for mechanical removal of loosely adherent microorganisms (transient microorganisms) and other organic matter but not effective in removing micro flora of the hands (Kampf and Kramer, 2004).

Marzona and Balzaretti (2013) reported of 81.5% (percentage of staff with effective hand wash results) satisfactory results in Italian schools, Tan *et al* (2013) equally reported ACC mean of 1.56±0.58 $Log_{10}CFUcm^{-2}$ in Malaysian schools. These schools already had HACCP in place and hand sanitizers were incorporated in hand washing procedures. Nhlapo *et al* (2014) who worked on staff hand hygiene in South African schools reported 60% satisfactory results which was equally better than this Ghanaian case as even though there were reductions in ACC levels across categories none of the schools met the 1.3 $Log_{10}CFUcm^{2}$ guideline. Coliforms had a significant log reduction of 2.01 $Log_{10}CFUcm^{-2}$ with a Post GHP range of 4.00 - 1.01 $Log_{10}CFUcm^{-2}$. Schools mean after GHP was 2.26±1.13 $Log_{10}CFUcm^{-2}$. One school met the 1 $Log_{10}CFUcm^{-2}$ advisory guideline for coliforms (Sneed *et al* 2004, Santana *et al* 2009, Marzona and Balzaretti, 2013) on cleaned food contact surfaces whilst four others were < 2 $Log_{10}CFUcm^{-2}$. Good hygiene category schools had the least mean of 2.11±1.15 Log_{10} $CFUcm^{-2}$ followed by poor hygiene schools with medium schools having the highest. Santana *et al* (2009) reported of absence of coliforms on cleaned surfaces after GHP intervention. This was not the case with the Ghanaian schools. Marzano and Balzaretti (2013) reported of 88.2% satisfactory results (number of staff with effective hand wash results) in Italian schools but they also had the use of sanitizing as part of their hand washing procedure.

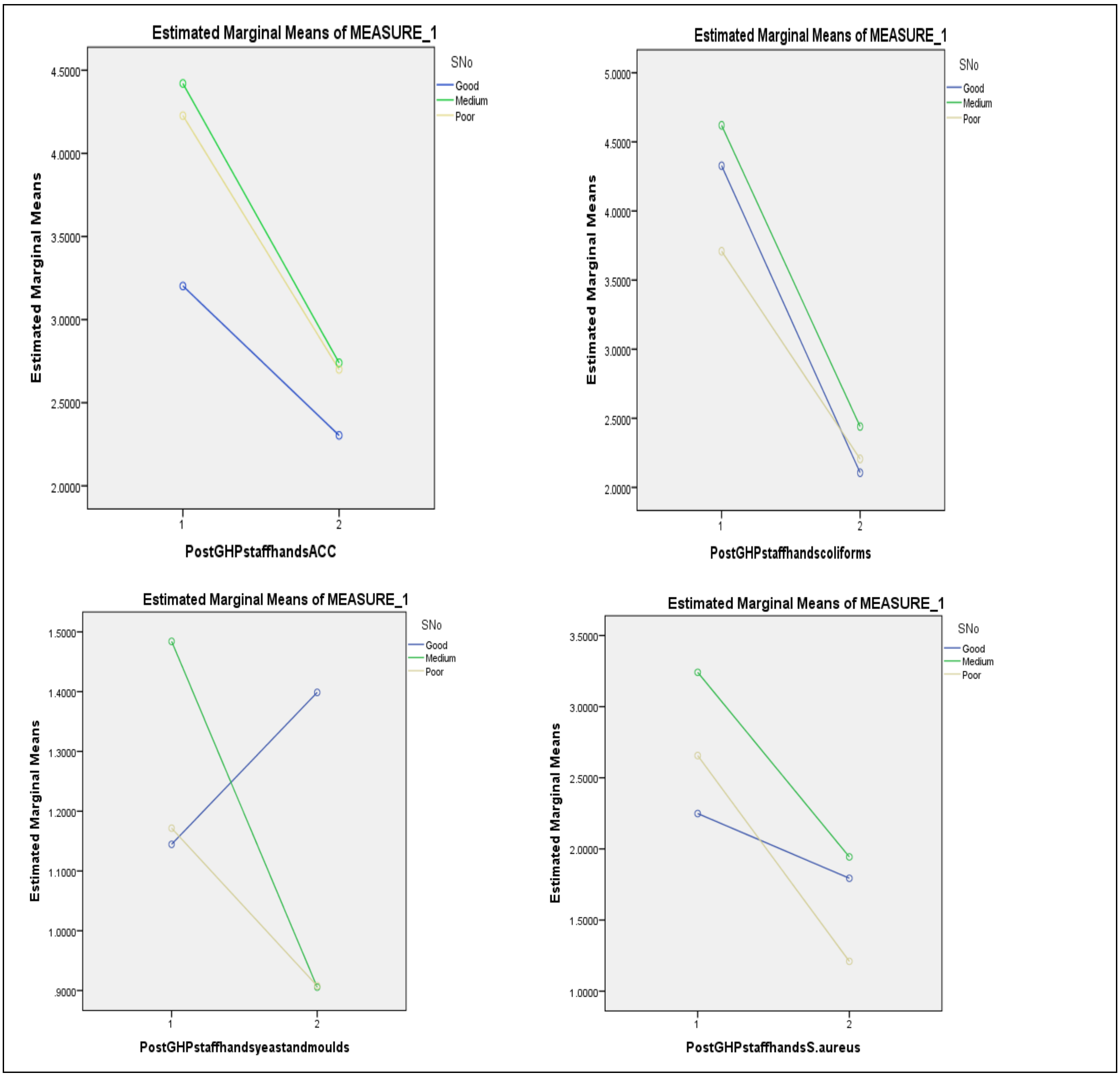


Fig. 15. GHP intervention effect on microbiological load on staff hands after washing

Yeast and mould Post GHP reduced by 0.22 $Log_{10}CFUcm^{-2}$ with a new schools mean of 1.09±0.79 $Log_{10}CFUcm^{-2}$. Six schools (55%) met the 1 $Log_{10}CFUcm^{-2}$ of the Agriculture Food and Rural Development of Manitoba (2013). With the exception of Nhlapo *et al* (2014) none of the authors investigated yeast and moulds on hands and they reported 60% satisfactory results in South African schools which was slightly above the Ghanaian case. Whereas these South African schools had disinfectants, they blamed kitchens not properly enclosed to prevent dust and other environmental effect on food preparation conditions and also inadequate contact time and dilutions for disinfectants for the cause of unsatisfactory results. Whilst medium and poor hygiene category schools mean for yeast and mould decreased after GHP intervention, good hygiene schools mean increased instead of reducing in two schools and was the only category with mean above the advisory limit. This could be due to other environmental factors or type of meal prepared on the day as staff hands washing procedure was similar (water with plain soap) in all schools. Staff in school O10 for instance were cleaning dried corn husk towards 'kenkey' preparation on this visit. Other practices like groundnut sorting and picking for soup preparation could also affect yeast and mould levels in the environment.

Coagulase positive *Staphylococcus aureus* were absent from staff hands Post GHP intervention unlike the Brazilian schools where there were coagulase positive *S. aureus* on staff hands in medium hygiene category school. The Post GHP *S. aureus* mean in Ghana was 1.69±1.39 $Log_{10}CFUcm^{-2}$ with a log reduction of 1.03.

Table. 31. Wilcoxon's signed rank test on staff hand hygiene after GHP intervention

Treatments	**N**	**Z**	**p(1-sided)**
Pre-post GHP ACC	11	-1.956	0.027*
Pre-post GHP Coliforms		-2.401	0.007*
Pre-post GHP Yeast and moulds		-0.178	0.449
Pre-post GHP *S. aureus*		-1.689	0.051

This 1 log reduction was similar to the 1.1 log reduction reported in medium hygiene schools from Brazil even though there was the use of a disinfectants (Santana *et al* 2009). Three schools (27%) met the advisory level of 1 $Log_{10}CFUcm^{-2}$ for food contact surfaces. Thus GHP intervention helped improve staff hand washing practices.

Wilcoxon's signed-rank test was used to compare the effect of GHP intervention on microbiological load on staff hands after cleaning (Table 31). Both ACC and coliform levels were significantly reduced Post GHP ($p \leq 0.05$). Although there were reductions in yeast and mould and *S. aureus* levels these were not significantly different from Pre GHP levels.

4.4.5 Effect of GHP training on cleaning practices among the selected schools

Schools were informed to use warm water in cleaning during training in the absence of sanitizers for surfaces. This practice was however met with difficulty due to lack of readily available heated water from taps. Only school 003 was able to erect a separate water boiling area for pantry men to aid washing.

4.4.5.1 *Serving Pans /dishes*

There were reductions in ACC, total coliforms and yeast and moulds levels on serving pans (Plate 28) after the GHP intervention (Table 32).

Plate 28. Serving pans

The Post GHP ACC range was 1.96 – 4.58 from a Pre GHP range of 2.97- 6.60 Log. The overall school log reduction was 0.86 for ACC. All the schools in the three categories reduced

ACC levels on pans Post GHP with the exception of schools O20 and OO2 and OO7 which did not reduce but slightly increased by 1.53, 0.71 and 0.10 Logs respectively. The ACC mean log reductions on pans for all the three categories were, 0.20, 1.95, 0.27 for poor, medium and good hygiene category respectively. Whilst in Brazilian schools Santana *et al* (2009) reported of 3 log reductions on serving plates from poor hygiene schools but rather a 2.6 log increase (3.5 to 6.10 Log) on similar equipment from medium hygiene category school Post GHP intervention. There were no serving plates for the excellent hygiene category school in Brazil. Three schools OO1, O10 and O19 Post GHP intervention had pans which could be regarded as acceptable (<1.64-2.41 $Log_{10}CFUcm^{-2}$) in school kitchens by the Agriculture, food and rural development of Manitoba standard (2014).

Table 32 Microbiological contaminants on serving pans after GHP intervention

		Microbiological count in $Log_{10}CFUcm^{-2}$					
Hygiene category	**Sch-ools**	**Pre ACC**	**Post ACC**	**Pre Coliforms**	**Post Coliforms**	**Pre Yeast and moulds**	**Post Yeast and moulds**
Advisory guideline		1.3		1.0		1.0	
Good	OO7	4.08	4.18	1.86	4.42	1.63	0.75
	O10	3.04	1.96	2.31	1.18	1.15	0.13
	O19	2.97	2.41	4.19	2.19	2.68	3.00
	O26	3.33	3.81	2.48	4.11	4.02	0.34
Category mean		3.36±0.51	3.09±1.07	2.71±1.02	2.97±1.55	2.37±1.27	1.05±1.32
Medium	OO2	3.85	4.56	2.85	5.60	3.82	3.00
	OO3	6.42	3.53	7.60	3.56	2.06	0.25
	OO5	6.60	3.53	5.58	4.23	2.54	3.00
	O12	6.60	4.07	6.60	3.30	1.36	0.42
Category mean		5.87±1.35	3.92±0.49	5.66±2.05	4.17±1.03	2.45±1.04	1.67±1.54
Poor	OO1	3.47	2.38	6.60	1.53	2.11	0.45
	OO4	3.74	2.70	3.54	2.28	1.04	0.53
	O20	3.05	4.58	3.31	4.42	2.19	0.67
Category mean		3.42±0.35	3.22±1.19	4.48±1.84	2.74±1.35	1.78±0.64	0.55±0.11
Schools mean		4.29 ±1.49	3.43±0.93	4.26±2.00	3.35±1.39	2.23±0.99	1.14±1.21

Coliform levels on pans after GHP intervention equally reduced for all the hygiene categories with the exception of good hygiene category which increased slightly by 0.26 Log (Fig 16). The range for coliforms on pans Post GHP was 1.18 – 5.60 as compared to Pre GHP range of 1.87 - 7.60 $\log_{10}$ CFU cm^{-2} with an overall schools mean reduction of 0.91 Log_{10} CFU cm^{-2}. The mean reduction for poor and medium hygiene category schools were 1.74 and 1.49 Log_{10} $CFUcm^{-2}$ respectively Post GHP intervention.

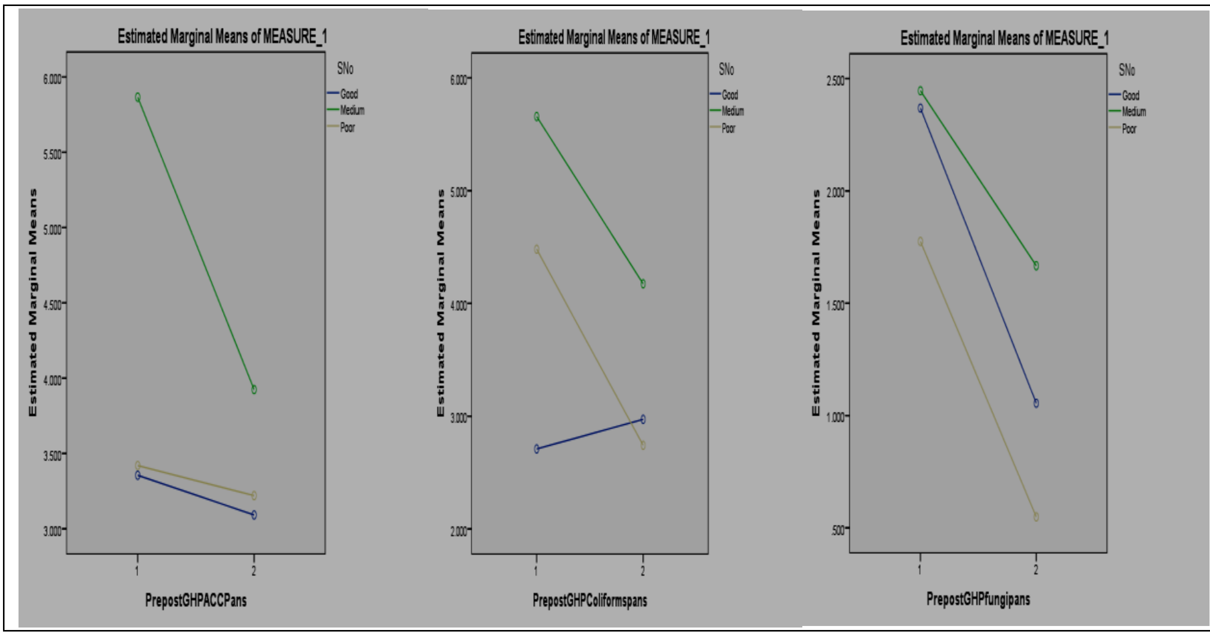


Figure 16. Microbiological contaminants on serving pans after GHP intervention

Two schools, OO1 and O10 were close to the advisory standard of 1 $Log_{10}CFUcm^{-2}$ for total coliforms on cleaned food contact surfaces used by Sneed *et al* (2004) and Marzano and Balzaretti (2013). Santana *et al* (2009) did not evaluate coliforms on food contact surfaces after GHP intervention in Brazil. The Post GHP range of 1.18-5.60 Log were higher than the report from Italian schools with 98.6% of 139 food contact surfaces conforming with the 1.0 $log_{10}CFUcm^{-2}$ (Marzano and Balzaretti, 2013) and in Iowa where 95% of mixing bowls were equally in conformity (Sneed *et al* 2004) although these included a sanitizing stage in their cleaning process. It was also higher than those from South African schools where 40% of sampled surfaces were in conformity as reported by Nhlapo *et al* (2014) with a highest count of 1.6 log on preparation tables after cleaning.

Yeast and moulds equally reduced across all the categories. The Post GHP range was 0.13 – 3.00 from a Pre GHP range of 1.04 - 4.02 Log_{10} CFU cm^{-2}. Log reductions across the hygiene categories were 1.23, 0.78 and 1.32 for poor, medium and good hygiene categories respectively. Sneed *et al* (2004), Santana *et al* (2009) and Marzano and Balzaretti (2013) did not work on yeast and moulds on food contact surfaces. Nhlapo *et al* (2014) reported of 40% satisfactory results (≤1 Log_{10} CFU cm^{-2}) in South African schools. There were 72.7% satisfactory results from this report on yeast and mould levels on pans Post GHP intervention according to the Agriculture, Food and Rural Development of Manitoba (2014) guidelines. Thus yeast and moulds levels on pans in schools Post GHP intervention significantly improved and met the acceptable guidelines. Since infrastructure had not changed, effective cleaning procedure and maintenance of storage area seemed to have positively affected levels of yeast and mould on food contact surfaces.

4.4.5.2. *Effect of GHP intervention on cleaning practices of kitchen staff- serving ladles*

Plate 29. Serving ladles being swabbed

Ladles (Plate 29) were used to serve food after cooking in the dining halls. The Post GHP ACC range was 2.05 - 4.60 from a Pre GHP range of 3.16 - 6.60 $Log_{10}CFUcm^{-2}$. There was a significant 1.82 log reduction in the schools ACC count Post GHP intervention. With the exception of school O20 which did not reduce but had a 1.19 log increase after training, all the schools from all the categories reduced ACC levels on ladles Post GHP intervention (Table 33). None of the schools ladles met the advisory level of 1.3 log for ACC after cleaning used by Sneed *et al* (2004), Santana *et al* (2009) nor Marzano and Balzaretti (2013). Santana *et al* (2009) reported of 1.6, 0.8 and 2 log reductions on ladles from poor, medium and excellent hygiene category schools Post GHP intervention. In the Ghanaian schools Post ACC mean log reduction on ladles equally reduced by 0.66, 2.69 and 1.83 Logs for poor, medium and good hygiene category schools respectively. Total coliforms on ladles reduced with a school log reduction of 2.14 $\log_{10}$ cm^{-2} and a mean of 3.02 ± 1.36 Log_{10} cm^{-2}. The Post GHP range was 1.60 -5.61 Log_{10} cm^{-2} from a Pre GHP range of 1.00-7.60 Log_{10} cm^{-2}.

Table 33. Microbiological contaminants on serving ladles Post GHP intervention.

		Microbiological count in $Log_{10}CFUcm^{-2}$					
Hygiene category	**Schools**	**Pre ACC**	**Post ACC**	**Pre Coliforms**	**Post Coliforms**	**Pre Yeast and moulds**	**Post Yeast and moulds**
Advisory guideline		**1.3**		**1.0**		**1.0**	
Good	OO7	5.17	4.41	6.60	4.49	1.64	3.35
	O10	6.60	2.27	6.60	2.25	1.28	1.11
	O19	3.11	2.16	2.32	1.60	2.48	0.60
	O26	5.13	3.86	5.53	3.91	3.23	0.34
Category mean		5.00±1.43	3.17±1.13	5.26±2.03	3.06±1.36	2.16±0.87	1.93±1.29
Medium	OO2	5.16	4.60	4.66	5.61	3.54	3.00
	OO3	6.48	3.46	7.60	2.72	4.00	1.72
	OO5	6.60	2.93	6.60	2.71	3.27	2.01
	O12	6.60	3.09	6.60	2.08	3.72	1.99
Category mean		6.21±0.70	3.52±0.76	6.37±1.23	3.28±1.58	3.63±0.31	1.67±1.54
Poor	OO1	3.16	2.53	3.60	1.72	0.90	3.75
	OO4	4.58	2.05	5.60	1.79	1.83	1.08
	O20	2.96	4.15	1.00	4.38	1.34	1.53
Category mean		3.57±0.88	2.91±1.19	3.40±2.31	2.63±1.51	1.36±0.46	2.12±1.43
Schools mean		5.05±1.46	3.23±0.93	5.16±2.06	3.02±1.36	2.48±1.12	2.11±1.04

All the categories equally reduced in coliform levels on ladles by 0.77, 3.03 and 2.20 log reductions for poor, medium and good hygiene category schools. Santana *et al* (2009) did not report on coliform levels on equipment sampled. Sneed *et al* (2004) reported on a coliform range of 1.0 – 4.13 Log_{10} cm^{-2} in Iowa with a mean of 2.55 ±3.33 $Log_{10}cm^{-2}$ on kitchen equipment after cleaning with 95% success. Thus coliform contamination was lower than the Ghanaian case. Marzano and Balzaretti (2013) reported 98.3% success on microbiological contaminants levels acceptability on serving ladles in Italian schools after standard cleaning and sanitising. None of the schools in Ghana came in conformity to the advisory standard of 1 Log_{10} cm^{-2} for coliforms on cleaned surfaces Post GHP intervention however three schools, OO1, OO4 and O19 had values < 2 Log_{10} cm^{-2}. There was an overall log reduction of 2.14 in the schools in Ghana for ladles. Yeast and moulds also reduced on ladles Post GHP intervention with a new range of 0.34-3.75 $Log_{10}CFUcm^{-2}$ from a Pre GHP range of 0.90-4.00. There was a 0.37 Log reduction on yeast and moulds in the schools. Medium and good hygiene category schools recorded 1.96 and 0.23 log reductions on ladles Post GHP.

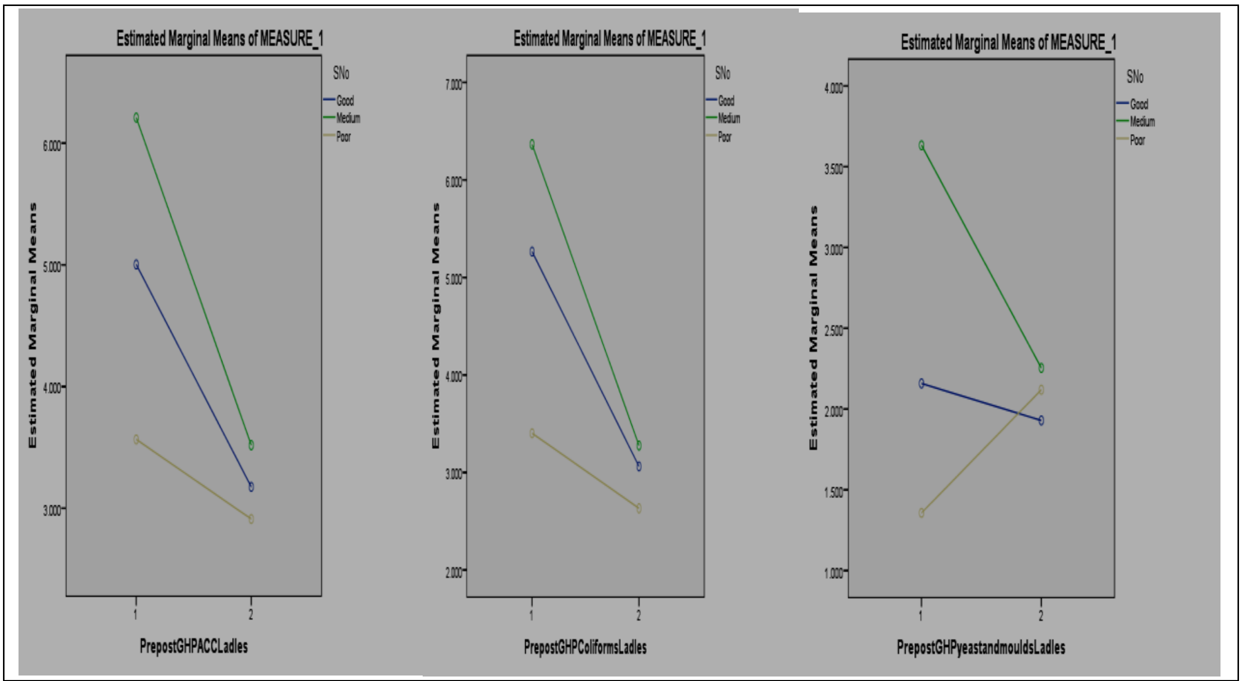


Fig. 17. Graphical presentation on microbiological contaminants on ladles after GHP

Poor hygiene schools however did not reduce but had a slight increase of 0.76 logs (Fig. 17) due to schools OO1 and O20 not reducing but increasing by 2.85 and 0.19 on yeast and mould counts Post GHP. School OO7 from good hygiene category school equally did not reduce but increased by 1.71 log Post GHP. Overall 2 schools from good hygiene category (18%) were in conformity with the advisory guideline of 1 Log_{10} $CFUcm^{-2}$ for yeast and moulds after cleaning set by Agriculture, Food and Rural Development in Manitoba (2014). Nhlapo *et al* (2014) reported of 40% satisfactory results from food contact surfaces in South African schools after cleaning. This was higher than the current report from Ghana. Santana *et al* (2009), Sneed *et al* (2004) and Marzano and Balzeretti (2013) did not enumerate yeast and moulds on food contact surfaces.

4.4.5.3. *Effect of GHP intervention on cleaning of kitchen knives*

Plate 30. Kitchen knife

There was an overall significant schools ACC reduction of 1.68 Log on knives (Plate 30) after GHP intervention with a mean of 3.45±0.93 $Log_{10}CFUcm^{-2}$. The Post ACC range on knives was 1.51-4.61 from a Pre GHP range of 1.82-7.20 $Log_{10}CFUcm^{-2}$. All the schools reduced in ACC levels with the exception of school O19 which had a log increase of 1.69 (Table 34, Figure 18). The log reduction across hygiene categories were 1.27, 2.66 and 0.99 for poor, medium and good hygiene schools. Two schools from poor hygiene category, OO1 (1.51 log_{10} CFU cm^{-2}) and OO4 (1.76log_{10} CFU cm^{-2}) were close to the 1.3 log advisory standard used by Santana *et al* (2009), Sneed *et al* (2004) and Marzano and Balzeretti (2013) but none of the schools came into conformity with the advisory standard for ACC Post GHP intervention.

Table 34. Comparing microbiological contaminants level on knives after GHP intervention

		Microbiological data in $Log_{10}CFUcm^{-2}$					
Hygiene category	**School code**	**Pre ACC**	**Post ACC**	**Pre Coliforms**	**Post Coliforms**	**Pre Yeast and moulds**	**Post Yeast and moulds**
Advisory guideline			**1.30**		**1.0**		**1.0**
Good	OO7	6.64	4.56	6.64	4.39	3.49	2.91
	O10	6.60	2.89	6.60	2.33	1.08	1.15
	O19	1.82	3.51	3.96	3.87	1.49	2.65
	O26	4.30	4.43	4.40	3.24	3.36	2.59
Category mean		4.84±2.29	3.85±0.79	5.41±1.42	3.46±0.89	2.35±1.25	2.32±0.79
Medium	OO2	5.23	4.61	4.71	4.61	2.63	3.92
	OO3	7.60	3.46	7.60	2.22	3.75	2.03
	OO5	6.60	3.73	6.61	4.25	2.29	3.00
	O12	6.60	3.73	3.62	2.68	3.65	2.26
Category mean		6.51±0.97	3.85±0.55	5.63±1.80	3.44±1.17	3.08±0.73	2.87±0.88
Poor	OO1	2.01	1.51	6.60	1.98	3.28	2.82
	OO4	4.73	1.76	5.12	1.08	3.13	2.15
	O20	4.29	3.96	3.10	2.75	3.03	2.38
Category mean		3.68±1.46	2.41±1.35	4.94±1.76	1.94±0.84	3.15±0.12	2.45±0.34
Schools mean		5.13±1.93	3.45±0.93	5.36±1.51	3.04±1.13	2.83±0.88	2.56±0.72

All schools significantly reduced level of coliforms on knives Post GHP intervention. There were 3.0, 2.19 and 1.95 log reduction on knives for poor, medium and good hygiene category schools. There was an overall schools log reduction of 2.32 with a mean of 3.04±1.13 $Log_{10}CFUcm^{-2}$. The Post GHP coliforms on knives significantly reduced with a range of 1.08-4.61 from a Pre GHP range of 3.10 -7.60. School OO4 with ACC of 1.08 log_{10} CFU cm^{-2} came into close conformity with the advisory standard of 1 $Log_{10}CFUcm^{-2}$ for coliforms on cleaned food contact surfaces. Whilst Santana *et al* (2009) did not report on coliforms on food contact surfaces, Sneed *et al* (2004) and Marzano and Balzaretti (2013) reported of 95% and 98% success of food contact surfaces meeting the 1 $Log_{10}CFUcm^{-2}$ in Iowa and Italy respectively although these schools included sanitizing in their cleaning. Nhlapo *et al* (2014) reported of 60 % satisfactory and 10% acceptable results from South African schools. Here 9.1% of the schools had satisfactory result for coliforms on knives.

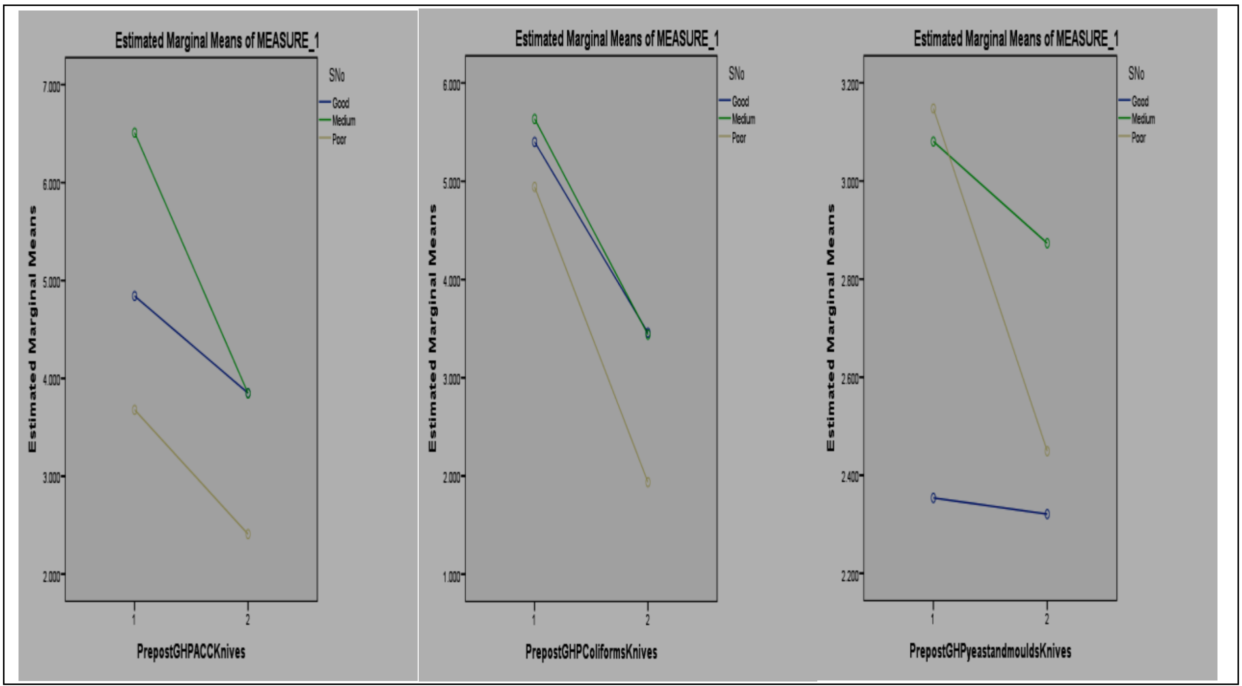


Fig. 18. Microbiological contaminants level on knives after GHP intervention

Yeast and moulds on knives also reduced for all the categories Post GHP intervention. There were 0.7, 0.21 and 0.03 log reductions for poor, medium and good hygiene category schools. The overall schools log reduction was 0.27 with a Post GHP range of 1.15-3.92 from a Pre GHP range of 1.08-3.75 $\log_{10}$ CFU cm^{-2}. School O10 came in close proximity to the yeast and mould guideline of 1 Log_{10} CFU cm^{-2} for cleaned food contact surfaces (Agriculture, Food and Rural Development of Manitoba, 2014). Nhlapo *et al* (2014) on the other hand reported of 40% satisfactory results in South African schools for yeast and moulds on food contact surfaces. Sneed *et al*, (2004), Santana *et al* (2009) and Marzano and Balzaretti (2013) did not report on yeast and mould count on food contact surfaces.

4.4.5.4. *Effect of GHP intervention on cleaning of grinders*

The level of ACC across the schools and categories significantly reduced on grinders (Plate 31) Post GHP intervention. The Post GHP ACC range was 2.39-4.71 $Log_{10}CFUcm^{-2}$ from a Pre GHP range of 3.61-6.60 $Log_{10}CFUcm^{-2}$. Log reductions were 1.28, 3.61 and 1.26 for poor, medium and good hygiene schools. The schools log reduction was 1.84 $Log_{10}CFUcm^{-2}$ with a mean of 3.32±0.93 $Log_{10}CFUcm^{-2}$. Sneed *et al* (2004) reported of an ACC mean of 2.64 ± 3.15 $Log_{10}CFUcm^{-2}$ for mixing bowls in Iowa with a range of 1.0-3.90 Log_{10} CFU cm^{-2}, cutting boards however had a mean of 3.35 ±3.90 $Log_{10}CFUcm^{-2}$ with a range of 1.0 - 4.70 $Log_{10}CFUcm^{-2}$ with a standard cleaning programme including sanitizing which is similar to the Post GHP mean on grinders in the Ghanaian case.

Plate 31. Grinder

Marzano and Balzaretti (2013) reported of 98.6% conformity with the advisory standard of 1.3 Log_{10} CFU cm^{-2} for ACC (Sneed *et al,* 2004 and Santana *et al,* 2009) on food contact surfaces including vegetable cutters. Here, in Ghana none of the schools was in conformity with the advisory standard. Santana *et al* (2009) did not work on grinders but reported of a mean of 3.5 Log and 4.4 Log on plates and spoons Post GHP intervention in poor and excellent hygiene schools. The current ACC load on grinders (3.32±0.93) was similar to ACC on plates but lower than that on spoons in Brazil Post GHP intervention. There were reductions in coliforms across all the hygiene categories on grinders (Table 35).

Table 35. Microbiological contaminant level on grinders after GHP intervention

		Microbiological data in $Log_{10}CFUcm^{-2}$					
Hygiene category	**School code**	**Pre ACC**	**Post ACC**	**Pre Coliforms**	**Post Coliforms**	**Pre Yeast and moulds**	**Post Yeast and moulds**
Advisory guideline		1.3		1		1	
Good	OO7	5.11	4.31	3.72	5.60	3.98	3.18
	O10	4.49	2.51	3.99	1.36	2.75	2.24
	O19	4.72	NA	4.54	NA	4.09	NA
	O26	3.61	2.87	3.44	1.18	2.28	1.62
Category mean		4.48±0.64	3.22±0.96	3.92±0.34	3.05±2.25	3.20±0.82	2.34±0.78
Medium	OO2	5.72	NA	3.43	NA	4.98	NA
	OO3	5.38	2.39	5.34	1.79	2.35	1.41
	OO5	N/A	NA	N/A	NA	N/A	NA
	O12	6.90	2.60	6.90	2.60	2.96	1.11
Category mean		6.10±0.80	2.49±0.17	5.22±1.74	2.21±0.57	3.43±1.78	1.24±0.23
Poor	OO1	6.60	3.14	6.60	2.83	4.02	2.26
	OO4	4.51	4.04	6.60	3.39	3.34	2.01
	O20	4.61	4.71	4.60	4.62	3.62	4.37
Category mean		5.24±1.18	3.96±0.78	5.94±1.15	3.61±0.92	3.66±0.34	2.88±1.31
Schools mean		5.16±1.01	3.32±0.93	4.92±1.36	3.05±1.44	3.44±0.86	2.27±1.06

NA- Equipment not available

Post GHP range was 1.18-5.60 from a Pre GHP range of 3.43-6.60 Log_{10} CFU cm^{-2}. Overall schools reduction was 1.84 Log with a Post GHP mean of 3.05±1.44 Log_{10} CFU cm^{-2}. This was still above the advisory standard of 1 log_{10} CFU cm^{-2} used by Sneed *et al* (2004) and Marzano and Balzaretti (2013). Santana *et al* (2009) did not evaluate coliforms on food contact surfaces but Nhlapo *et al* (2014) reported of 40% satisfactory results in South African schools.

There were reductions of 2.33, 3.01 and 0.87 logs across poor, medium and good hygiene category schools. Thus GHP intervention helped to improve microbiological contaminants load on grinders (Fig. 19). Yeast and moulds on grinders reduced across the schools with an overall significant school log reduction of 0.86 with Post GHP mean of 2.27± 1.06 $Log_{10}CFUcm^{-2}$ and a Post GHP range of 1.11 - 4.37 from a Pre GHP range of 2.28-4.98 Log_{10} cm^{-2}.

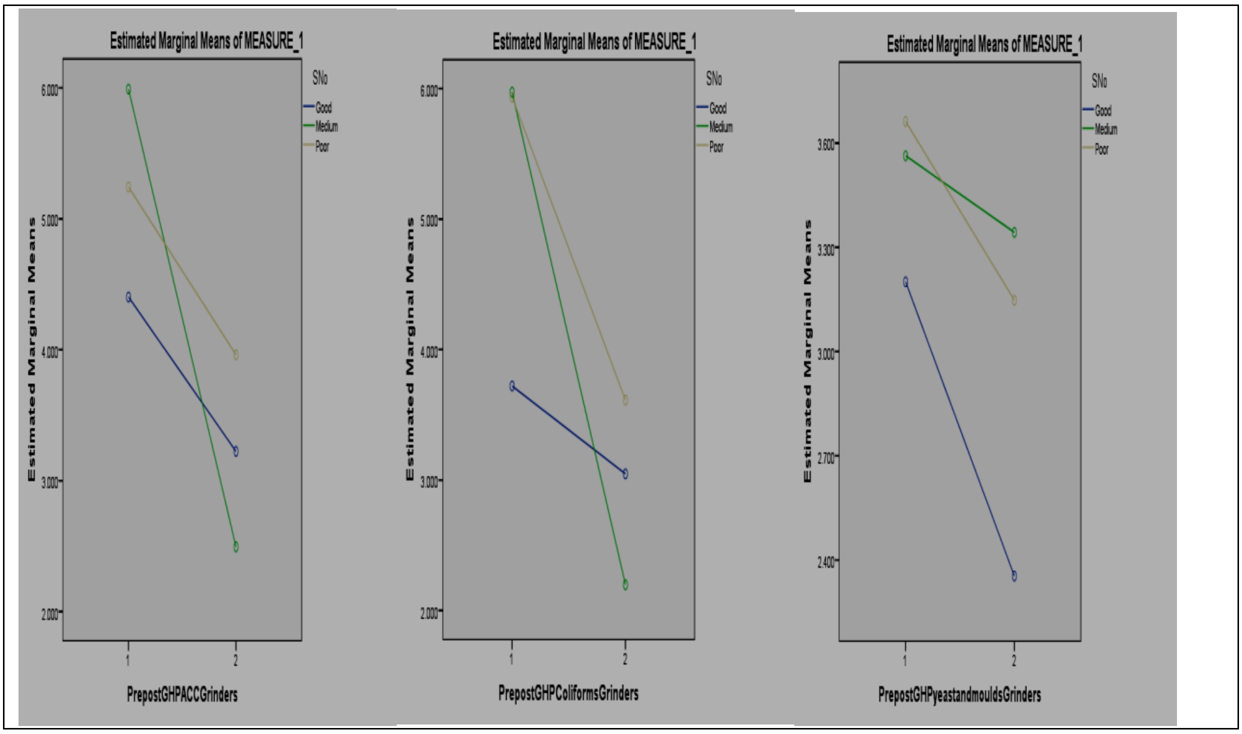


Fig 19. Graphical presentation of microbiological levels on grinders after GHP.

With the exception of school O20 which did not reduce but slightly increased there were log reductions across all schools and the categories with mean log reduction of 0.78, 2.19 and 0.86 for poor, medium and good hygiene schools. Three schools Post GHP intervention had yeast and mould loads on grinders close in conformity to the guideline of 1 $Log_{10}CFUcm^{-2}$ (Agriculture, food and rural development of Manitoba, 2014), although none met this. This was contrary to the South African situation where schools had 40% satisfactory results as reported by Nhlapo *et al* (2014).

4.4.5.5. *Statistical Analysis on the effectiveness of GHP intervention on cleanliness of food contact surfaces*

Wilcoxon's signed rank test, a non-parametric equivalent of dependent t-test for two related samples, was used to compare the Pre and Post GHP intervention microbial load on food contact surfaces to measure the effectiveness of GHP intervention on cleaning practices in the Ghanaian schools (Table 36). With the exception of ACC and coliforms on pans and yeast and moulds on knives and ladles, the Wilcoxon's signed- rank test indicated that the Post-GHP microbial levels (ACC, coliforms and yeast and moulds) on food contact surfaces were significantly lower ($p \leq 0.05$) than Pre GHP levels.

Table 36. Wilcoxon's signed rank test for microbiological contaminants on food contact surfaces Post GHP intervention

Test	**N**	**Z**	**p(1-sided test)**
Pre-Post ACC pans	11	-1.600	0.062
Pre-Post Coliforms pans	11	-1.067	0.160
Pre-Post yeast and moulds pans	11	-2.667	0.002*
Pre-Post ACC ladles	11	-2.490	0.005*
Pre-Post Coliforms ladles	11	-2.223	0.012*
Pre-Post yeast and moulds ladles	11	-1.156	0.139
Pre-Post ACC Knives	11	-2.401	0.007*
Pre-Post Coliforms knives	11	-2.934	0.001*
Pre-Post yeast and moulds knives	11	-0.800	0.232
Pre-Post ACC Grinders	11	-2.380	0.008*
Pre-Post Coliforms grinders	11	-1.960	0.027*
Pre-Post yeast and moulds grinders	11	-2.100	0.020*

$P \leq 0.05$

Thus 66.7% of the results were statistically significantly different (lower) Post GHP intervention. There was enough evidence using Wilcoxon's signed-rank test that GHP intervention reduced microbiological contaminants on food contact surfaces. Microbiological contaminants levels could be lowered further to meet the advisory guidelines.

4.4.6 *Summary*

Spearman's correlation test was conducted and Personal hygiene requirement scores (PHRs) after training significantly negatively correlated with jollof rice *Staphylococcus aureus* load, r = -0.682 (p=0.021). This supports Santana *et al* (2012) on the positive effect of GHP training on practices of staff towards food safety. Coagulase positive *Staphylococcus aureus* were not identified Post GHP intervention in food and on staff hands. After training there was a significant negative correlation between Personal Hygiene Requirement scores (PHKs) and *S. aureus* load in jollof rice.

Table 37. Spearman's correlation (R) and significance level (p) of selected variables Post GHP intervention

	Post jollof ACC	**Post jollof *S. aureus***	**Post jollof coli-form**	**Post jollof Yeast & Mould**	**Post jollof *B. cereus***	**Post hand coli-forms**	**Post hand *S. aureus***	**Post food temp.**	**Post Food holding time**
Post Personal hygiene Score		-0.682* (0.02)			-0.183 (0.59)				
Post Food hygiene knowledge scores	0.222 (0.50)	-0.474 (0.14)	-0.260 (0.44)	-0.296 (0.38)	0.446 (0.17)	-0.260 (0.44)	-0.474 (0.14)	0.462 (0.15)	-0.206 (0.54)
Post food waiting time	0.566 (0.07)	0.453 (0.16)							

p≤ 0.05

Thus as personal hygiene practices of staff improved, *S. aureus* levels in cooked jollof reduced. Food Hygiene Knowledge scores seemed to increase with decreasing microbiological contaminants in jollof rice (Table 37) although these were not significant. This could also directly affect the improvement in food safety and thus reduce the hazards associated with jollof rice. Coliforms and coagulase negative *S. aureus* on staff hands also negatively correlated with Post GHP FHKs although not significant. Thus as FHKs increased hand washing seemed to improve. Post GHP ACC load weakly positively correlated with Food Hygiene knowledge after training (0.222, p=0.50) this was not significant. Although a quality and contamination indicator, an increase could be a risk as potential disease causing microorganisms could go up to disease causing levels. ACC load $\geq 5 \log_{10}$ have also been associated with temperature abuse of food (HPA, 2009) and product nearing its shelf life. *Bacillus cereus* load in rice was not significantly affected by the intervention and also weakly positively correlated with Food Hygiene Knowledge intervention (r=0.446, p=0.17). Current practices after training seems not to have positively affected *Bacillus cereus* load on food. Cooked rice is highly associated with *B. cereus* poisoning as the spores have been reported in rice. Poor processing and abused food holding temperatures aid regeneration of spores and multiplication of cells leading to toxin production and subsequent food poisoning. Thus improved personal hygiene could not have positive effect on *B. cereus* reduction although an improved holding temperature and time could. Cross contamination from food contact surfaces was also possible. The ability of food pathogens to rapidly grow in the absence of competitive microorganisms is possibly depicted by *B. cereus* in this report also. Post GHP food waiting time negatively correlated with food hygiene knowledge scores although it was not significant. Thus training intervention helped reduce the time cooked and served jollof rice spent out of controlled temperature which is also a positive food safety issue. ACC and *Staphylococcus aureus* load in jollof rice positively correlated with food waiting time (Table 37) although not significantly different. Jollof rice as shown in Plate (30) was served in aluminium pans (non-temperature controlled equipment) and reduced waiting times to meals Post GHP training decreased levels of ACC and *S. aureus*. Although not meeting the stated guidelines, GHP intervention decreased microbial load and thus improved cleanliness of kitchen equipment and staff hands and thus positively affected food safety.

4.4.6.1 *Comparing current data with Brazilian school report (Santana et al 2009) and street food in capital city in Ghana (Mensah et al 2002)*

Aerobic colony counts for ready to eat meals from the cook-serve kitchens in both countries reduced Post GHP intervention with 80% and 100% of sampled foods meeting the satisfactory results (4 $Log_{10}CFUg^{-1}$) in Ghana and Brazilian schools respectively. Some common factors used by both researchers that worked were the staff hygiene training and temperature and time monitoring.

Table 38. RTE microbiological contaminants Pre-Post GHP in schools in Ghana and Brazil and a street food in Ghana

			RTE cooked meals mean data in $Log_{10}CFUg^{-1}$		
Country	**Micro organism**	**Number of schools (N)**	**GS 955: 2013**	**Pre intervention (% satisfactory)**	**Post GHP Intervention (% satisfactory)**
Ghana Schools	ACC	11	4	5.84±2.17(20.0)	3.72±0.64(80.0)
Brazil schools		3		3.33±1.64 (67.0)	1.83±0.21 (100.0)
Accra-Vendors		*20		3.3±1.80	N/A
Ghana schools	Coli - forms	11	2	4.45±2.04(0.0)	3.06±0.89(40.0)
Brazil		3		N/S	-(100.00)
Accra-Vendors		*20		1.0±1.43	N/A
Ghana	Yeast and mould	11	3	4.11±1.45 (20.0)	2.35±0.55(80.0)
Brazil schools		3		N/A	N/A
Accra-Vendors		*20		N/A	N/A
Ghana schools	*S. aureus*	11	2	4.31±1.63(40.0)	2.06±0.13(80.0)
Brazil schools		3		N/S	-(100.00)
Accra-Vendors		*20		2.0±2.04	N/A
Ghana schools	*B. cereus*	11	2	3.26±0.58(0)	3.42±1.41(40.0)
Brazil schools		3		N/A	N/A
Accra-vendors		*20		0.5±1.33	N/A

***Some of the vendors prepared meals for pupils, N/S- Not stated, N/A Not applicable**

Staff hygiene knowledge and practices scores improved after training in Ghana (Table 23), and in Brazil. Santana *et al* (2009) highlighted employee hygiene practices and food safety in terms of improved microbiological quality of food. These GHP practices required staff preparedness to comply with decided terms of operation without any related cost. Marzano and Balzaretti (2013) equally concluded that time of food preparation and holding temperatures provided a higher hygienic protection for RTE meals. Street vendors sampled food in the capital city-Accra ACC levels in 'wakye' (rice cooked with beans) met the national standard (GS 955:2013) of 4 $Log_{10}CFUg^{-1}$ (Mensah *et al*, 2002) although Macaroni for instance had 6.0±1.64 $Log_{10}CFUg^{-1}$ which was above the national standard. Differences in the two street foods were probably due to different methods of serving after preparation. Feglo and Sakyi (2009) equally reported of 5.48 ± 0.97 $Log_{10}CFUg^{-1}$ for ACC in cooked macaroni in Kumasi street foods. Thus without food hygiene training, ACC levels in both street foods and school meals could be high, which however, could be reduced after hygiene intervention. Santana *et al* (2009) reported absence of coliforms and *S. aureus* in food Post GHP intervention but did not give initial figures, neither was yeast and mould levels conducted in Brazil. This was not so with Ghana, as coliforms were still present but reduced by 1.39 Log Post GHP with 40% of the schools meeting the national acceptable level of 2 Log_{10} $CFUg^{-1}$ (GS 955: 2013). Eighty percent (80%) of schools sampled also met the 3 and 2 $Log_{10}CFUg^{-1}$ national level for cooked rice meals for yeast and mould and *S. aureus* respectively Post GHP (Table 38). Only *Bacillus cereus* level did not reduce but slightly increased Post GHP intervention. The organism was not analysed in Brazil by Santana *et al* (2009). Post GHP ACC, coliforms and *S. aureus* were significantly ($p \leq 0.05$) reduced (Table 29).

The levels of ACC on staff hands from Brazilian schools reduced by 3.18 $Log_{10}CFUcm^{-2}$ although this could not meet the 1.3 $Log_{10}CFUcm^{-2}$ advisory guideline (Sneed *et al*, 2003, Santana *et al* 2009, Marzona and Balzaretti, 2013 and Osimani *et al* 2011). In Ghana and with social hand washing (plain soap and water) there was 1 Log reduction only Post GHP intervention which equally could not meet the agreed guideline. Watutantrige *et al* (2012) had earlier reported of plain soap ability to reduce microbial contaminant more than only water handwashing although the differences were small. (With soap: without soap left hand- 3.32±0.82: 3.81±0.61). Kampf and Kramer (2004) mentioned a limitation of plain soaps removing only transient microorganisms but not micro flora of the hands. This could be the reason for the result from Ghana.

Table 39. Staff hand hygiene Pre-Post GHP training in Ghana and Brazilian schools

		Staff hand mean microbial load ($Log_{10}CFUcm^{-2}$)			
		Disinfectant in use		**Plain soap in use**	
Treatments	**Advisory standard Log_{10} CFU cm^{-2}**	**Brazilian staff Santana *et al* (2009) N=5**	**Log reductions**	**Ghanaian Schools kitchen staff N=11**	**Log reductions from Pre GHP**
ACC Pre GHP	1.3	5.12±1.33		3.92±1.28	1.35
ACC Post GHP		1.94±1.03	3.18	2.57±0.88	
Coliforms Pre GHP	1.0	N/S	-	4.27±1.68	2.01
Coliform Post GHP		N/S	-	2.26±1.13	
Yeast and moulds Pre GHP	1.0	N/A	-	1.31±1.15	0.22
Yeast and moulds Post GHP		N/A	-	1.09±0.79	
S. aureus Pre GHP	1.0	N/S		2.72±1.17	1.03
S. aureus Post GHP		N/S	N/S	1.69±1.32	

N/S- done but not stated, N/A- not done

Santana *et al* (2009) apart from ACC did not state the initial levels or means of coliforms and *S. aureus* on staff hands and did not report on yeast and moulds. In Ghana there were 2.02, 0.19 and 1.03 Log reductions for coliforms, yeast and mould and *S. aureus* levels on staff hands Post GHP training. These however could not meet the agreed guideline of 1 $Log_{10}CFUcm^{-2}$ used by Sneed *et al*, (2003), Marzona and Balzaretti, (2013) and Osimani *et al* (2011) for coliforms and *S. aureus* and 1 $Log_{10}CFUcm^{-2}$ guideline by the Department of Agriculture, Food and Rural Development of Manitoba (2014) for yeast and mould . The absence of coagulase positive *S. aureus* in the Ghanaian schools was however different from Brazil where medium schools still had them on one staff hand but with 1 Log reduction. The Ghanaian case could be due to the absence of anti-bacterial soaps and clean disposable towels for hand washing due to economic reasons. Although during training staff were told to carry along clean hand towels specifically for their hand washing. As indicated already social hand washing (plain soap and water) probably could not effectively remove the microflora on staff hands although transient ones could be successfully removed and absence of clean disposable towels could not help the Ghanaian case.

Table 40. Comparing microbial contaminants on food contact surfaces in Ghana and Brazilian schools after GHP training

		Total utensils mean microbial load ($Log_{10}CFUcm^{-2}$)			
		Disinfectant in use		**Plain soap in use**	
Treatments	**Advisory guideline**	**Brazilian Schools FCS N=9**	**Log reduction**	**Ghanaian Schools FCS N=44**	**Log reductions**
ACC Pre GHP	1.3	5.33±1.46	1.01	4.91±1.51	1.55
ACC Post GHP		4.32±1.06		3.36±0.92	
Coliforms Pre GHP	1.0	N/S	N/S	4.92±1.76	1.80
Coliform Post GHP		N/S		3.12±1.28	
Yeast and moulds Pre GHP	1.0	N/A	N/A	2.72±1.03	0.73
Yeast and moulds PostGHP		N/A		1.99±1.12	

FCS- Food contact surfaces, N/S- done but not stated, N/A- not done

The mean ACC load on utensils in both Brazil and Ghana were high Post GHP and though there were 1.01 and 1.55 Log reductions, Post GHP ACC still were high and did not meet the agreed guideline of 1.3 $Log_{10}CFUcm^{-2}$ (Sneed *et al*, 2003, Santana *et al* 2009, Marzona and Balzaretti, 2013 and Osimani *et al* 2011). The coliform levels before and after GHP were not given by Santana *et al* (2009) although they mentioned absence Post GHP intervention. Levels in Ghana reduced by 1.80 $Log_{10}CFUcm^{-2}$ but could not meet the agreed guideline. Yeast and mould levels were not enumerated in Brazil and in Ghana there was 0.73 Log reduction Post GHP intervention. The probable causes for the high microbial contaminants on utensils in the Ghanaian case could still be due to absence of sanitizing stage in cleaning and absence of heated water. Although in Brazil a disinfectant was in use, the Post GHP ACC mean was still high (Table 40). Water used for cleaning in Ghana could also be a factor although this was not investigated.

4.5. Effect of HACCP intervention on food safety and staff hygiene practices in Ashanti Region of Ghana

Letters for approval from heads of institutions for the second intervention (HACCP), available infrastructure, matrons and kitchen staff commitment were the criteria used for this stage of intervention. Out of the 11 schools only one headmaster was not prepared for further work on HACCP, 6 of the schools had matrons who were not committed to keeping records given to aid the GHP practices (Appendix 5) and 4 out of these 6 had poor infrastructure and facility issues (Plate 13). Hence the rest of the schools (5) that were available, had the needed infrastructure (Plate 32 and 33) and showed commitment were chosen.


Plate 32. Cooking space in a good hygiene category school. Plate 33. Hand washing facility, soap and towel for drying of hands on toilets in good hygiene category school

4.5.1 ***Effect of HACCP intervention on food temperature and time control in SHS school kitchens***

Plate 34: Food being dished into pans **Plate 35. Dished food in pans ready for transport**

Plate 36. Dished food being taken to dining hall. **Plate 37. Dished food on tables awaiting students**

Kitchen staff were trained to keep the hot holding temperature of food at 63 °C. Dishing of jollof rice was to start an hour to dining time as dishing staff and pantry (serving) men took between 30 to 60 minutes to complete serving food for over 2000 students per meal. Matrons were to ensure that food did not wait more than an hour after cooking before meal time began and hot holding temperature was to be attained during this period (Plate 34-37). Cooking of jollof rice which took approximately 3 hours with a cooked food temperature >80.0 ℃ was therefore to be monitored to ensure that food was cooked and ready to be dished just an hour before meal time as 1 hour after cooking the acceptable hot holding temperature, 63℃ is attainable in an uncontrolled environment (Dablool *et al*, 2014). Temperature and time of cooked and served meals were to be monitored on related records with food temperature probe (Plates 5 and 8).

Table 41. Food holding temperature and time in 5 schools in Ghana Post HACCP

Variables	Number of schools	Mean	Mini-mum	Maxi-mum	Chi square, (p=0.05)	Stage of intervention	Post Hoc (1- tailed) p=0.016
Pre GHP Temp ℃	11	60.4±6.66	49.5	69.5	8.400(0.008)	Post GHP-Pre GHP	-2.625(0.003)
Post GHP Temp ℃	11	68.7±5.83	61.0	77.5		PostHACC-Pre GHP	-2.032(0.031)
Post HACCP Temp. ℃	5	73.2±4.84	65.5	77.5		PostHACC-Post GHP	-2.032(0.031)
Pre GHP Time (min)	11	57.9±30.23	27.5	120.0	2.842(0.270)		
Post GHP Time (min)	11	43.4±21.59	20.0	97.5			
Post HACCP Time (min)	5	38.4±12.76	30.0	60.0			

Bonferroni's correction = 0.05/3 =0.016. 6 schools absent at HACCP were considered missing data on SPSS

Food mean temperature across the 5 schools for cooked Ready-to-Eat meal (jollof rice) increased substantially Post HACCP intervention with a mean temperature difference of 6.6 and 10.4 ℃ Post GHP and HACCP respectively. Whilst the minimum temperature Pre GHP was below the acceptable hot holding temperature of 63℃, Post HACCP minimum temperature was above this temperature. There was a significant difference in food temperature between Pre GHP, Post GHP and Post HACCP readings [χ^2 (2) =8.400, p=0.008] using Friedman's test. Thus the changes in temperature was unlikely to be by chance. Post Hoc test using Wilcoxon's signed-rank test with Bonferroni's critical significance indicated that GHP effected the significant change (p=0.003). Industrially HACCP is built on GHP (CAC, 2009, Sprenger, 2009) hence there is the interactive effect of GHP on HACCP. HACCP adds additional measures on GHP to improve on safety and this was evident as even though Post GHP temperature and Post HACCP temperature were both above the acceptable hot holding temperature at service, there was still an increase after HACCP, with the availability of monitoring equipment and records to complete. Food service time to meals also improved Post HACCP. There were mean reduction time of 14.4 minutes and 19.5 minutes Post GHP and Post HACCP respectively (Table 41). Thus staff had become conscious of the importance of managing food preparation and service time to ensure that food did not stay out of controlled temperature for longer period due to the absence of equipment to control food temperature in all the kitchens. Whilst after GHP there were some schools that were not able to reach this agreed time, Post HACCP data had 100% of schools conforming to this agreed standard. Thus after food was cooked, it was served within the suggested 30-60 minutes. This met the exact time students meal was due hence growth of microbiological cross contaminants or regeneration of spores was minimised. Although there were reductions in food holding time to meals times, the reductions from Pre GHP, Post GHP and Post HACCP were not significantly different using Friedman's Test for non-parametric data. Notwithstanding the agreed time during HACCP training was met. Santana *et al* (2009) in Brazil reported of improvement in food temperature at service across the 3 hygiene categories. The mean temperature Post GHP training was 61.10 ± 14.85 ℃ (45.6 -75.2 ℃) from a mean Pre GHP temperature of 58.0±16.83℃ (40.6 -74.2 ℃) (Fig. 20).

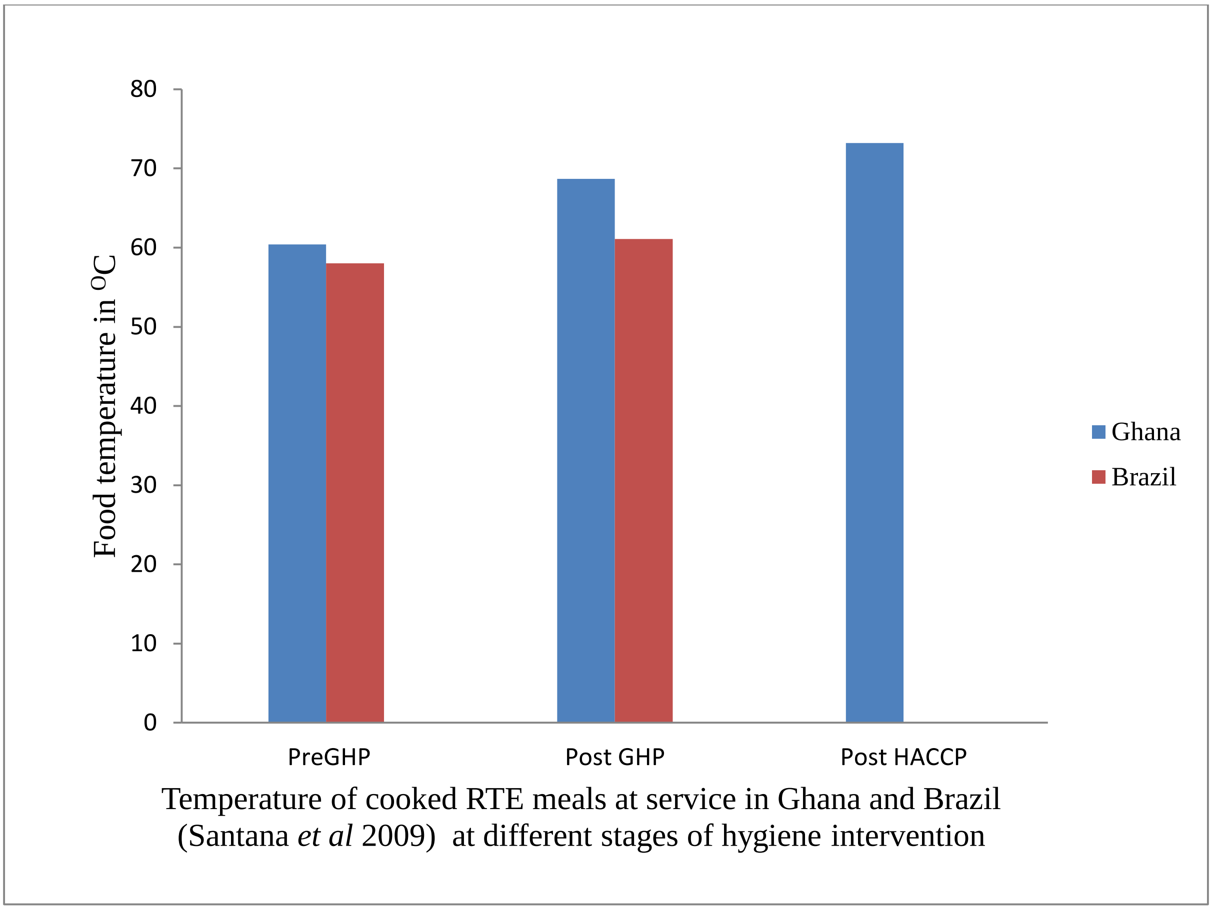


Fig. 20. Comparing food temperature at service before and after intervention in Brazil (Santana *et al* 2009) and Ghanaian schools

Thus there was an overall increment in food temperature control in Brazil although one of the schools still could not meet the acceptable hot holding temperature and the excellent hygiene school had a hot holding equipment in place. On the contrary all the Ghanaian schools met the agreed food holding and hot holding temperature Post HACCP even in the absence of hot holding equipment. Santana *et al* (2009) however did not continue with HACCP intervention whilst in Ghana temperature probes and records were provided for monitoring at HACCP stage. Marzona and Balzaretti (2013) in their work on school meals in Italian schools added that timing of the food preparation and hot holding temperatures provided a higher hygienic protection for RTE foods although temperature information was not added to the report. Osimani *et al* (2011) reported that a reduction in non-conforming samples on their temperature maintenance record reduced from 50% to 4.3% for cooked and warm-served products Post

HACCP intervention in university canteens which directly affected food quality. In Ghana there was 100% success with time and temperature control (Fig. 20).

4.5.2. *Effect of HACCP intervention on microbiological quality of jollof rice in Ghana*

Table 42. Microbiological contaminants level in jollof rice Pre GHP to Post HACCP

	Mean microbiological count in school meals in $Log_{10}CFUg^{-1}$					
		ACC (% satisfactory)	**Coliform** (% satisfactory)	**Yeast and moulds** (% satisfactory)	***S. aureus*** (% satisfactory)	***B. cereus*** (% satisfactory)
GS 955: 2013		4	2	3	2	2
Treatments	N					
Pre GHP	11	4.51±1`.28 (45.50%)	3.53±1.18 (0.0%)	2.93±0.72 (63.6%)	3.44±0.99 (9.0%)	3.29±0.83 (0.0%)
Post GHP	11	3.23±0.57 (81.90%)	2.81±0.59 (9.0%)	2.39±0.53 (80.8%)	2.12±0.24 (72.7%)	2.90±0.92 (27.3%)
Post HACCP	5	2.52±0.60 (100.0%)	2.27±0.32 (40.0%)	2.09±012 (100.0%)	2.10±0.22 (80.0%)	2.26±0.42 (60.0%)
Chi square (p=0.05)		6.40(0.039)	9.58(0.002)	6.00(0.054)	7.54(0.037)	3.11(0.259)
Post hoc (1 tailed) p=0.016	Post GHP-PreGHP	-1.956(0.027)	-1.778(0.042)		-2.803(0.001)	
	Post HACCP-Pre GHP	-2.023(0.031)	-2.023(0.031)		-1.826(0.063)	
	Post HACCP-Post GHP	-1.753(0.063)	-1.826(0.063)		-1.000(0.500)	

Food microbiological quality and safety improved as ACC, coliforms, yeast and mould, *S. aureus* and *B. cereus* for the 5 schools reduced Post HACCP intervention. ACC moved from 46% satisfactory at Pre GHP to 100% satisfactory status at Post HACCP with a schools mean of 2.52±0.60 $Log_{10}CFUg^{-1}$. The reduction of ACC levels across Pre GHP to Post HACCP was statistically significant, [χ^2 (2) = 6.400, p= 0.039] using Friedman's Test. Thus the interventions affected the reduction and was not by chance. Similarly coliforms reduced further Post

HACCP with schools mean of 2.27±0.32. This was however slightly above the GS 955: 2013 standard of 2 Log for farinaceous cooked Ready-to-Eat meals. The percentage of schools that met this satisfactory national standard moved from 0 to 40% Post HACCP. The reduction in coliform levels in cooked RTE food indicated general improvement in the hygiene practices as cooked food that reached cooking temperatures of 80.0℃ significantly reduced or eliminated vegetative cells including coliforms and food pathogens. The presence of coliforms in cooked meals indicates possible cross contamination and a reduction in levels indirectly infer to reduced sources of contamination from the environment and other raw or undercooked meals serving as vehicles of cross contaminants (Springer, 2009). The reduction in coliform levels across the three stages of the study was significantly different [χ^2 (2)=9.58, p=0.002] (Table 42). GHP and HACCP affected the reduction of coliforms in jollof rice.

All food samples met the national acceptable limit of 3 Log (GS 955: 2013) for yeast and mould in rice and other related cooked meals. There was an increase of percentage satisfactory level from 80% at Post GHP to 100% Post HACCP. Yeast and moulds levels could be from air due to lack of properly closed kitchens (Nhlapo *et al* 2014), raw materials and food contact surfaces. Since the former was still not corrected during HACCP, food contact surfaces including staff hands and utensils hygiene control through cleaning could have affected the improved levels. Avoiding over exposure of food to open air also could have affected the level. Yeast and mould levels even though there was 100% satisfactory results at Post HACCP the reductions were not significantly different from Pre GHP and Post GHP levels with the use of Friedman's Test [χ^2 (2)= 6.00, p=0.054].

Coagulase negative *Staphylococcus aureus* levels reduced at Post GHP and slightly reduced (0.02 Log) Post HACCP. Percentage of satisfactory levels increased by 7.3% from Post GHP to 80% Post HACCP. Coagulase negative *S. aureus* seemed to predominate in school meals. Feglo and Sakyi (2012) equally reported of their being one of the most prevalent bacteria types in street foods sampled in Kumasi alongside *Bacillus, Aeromonas, and Enterobacter* species. Friedman's test on effect of the interventions on *S. aureus* level in food was statistically significant (χ^2 (2)=7.54, p=0.037). Their reduction therefore could be due to improved personal hygiene practices in the kitchens. *Bacillus cereus* levels progressively reduced at Post GHP and Post HACCP stages. Percentage satisfactory levels moved from 0% at Pre GHP to 27% Post GHP and 60% at Post HACCP with all of the schools mean values < 3 $Log_{10}CFUg^{-1}$ Post HACCP. The reductions were however not significantly different. Jollof rice microbiological quality was improved significantly post GHP and HACCP interventions.

Post Hoc analysis with Wilcoxon's signed rank test and Bonferroni's critical significant correction of p=0.016 was used to test the effect of the two interventions on the Pre GHP – Post HACCP data for ACC, coliforms, and *S. aureus*. Post GHP - Pre GHP *Staphylococcus aureus* levels were significantly different at Z=-2.803 p=0.016. Post HACCP-Post GHP and Post HACCP- Pre GHP *S. aureus* were not significantly different with Wilcoxon's signed rank test and Bonferroni's correction. There was enough evidence that GHP intervention affected the reduction in *S. aureus* levels in jollof rice in the Ghanaian schools. Thus although HACCP brought about a continuous improvement on Post GHP, it was GHP intervention that caused the significant change in this report.

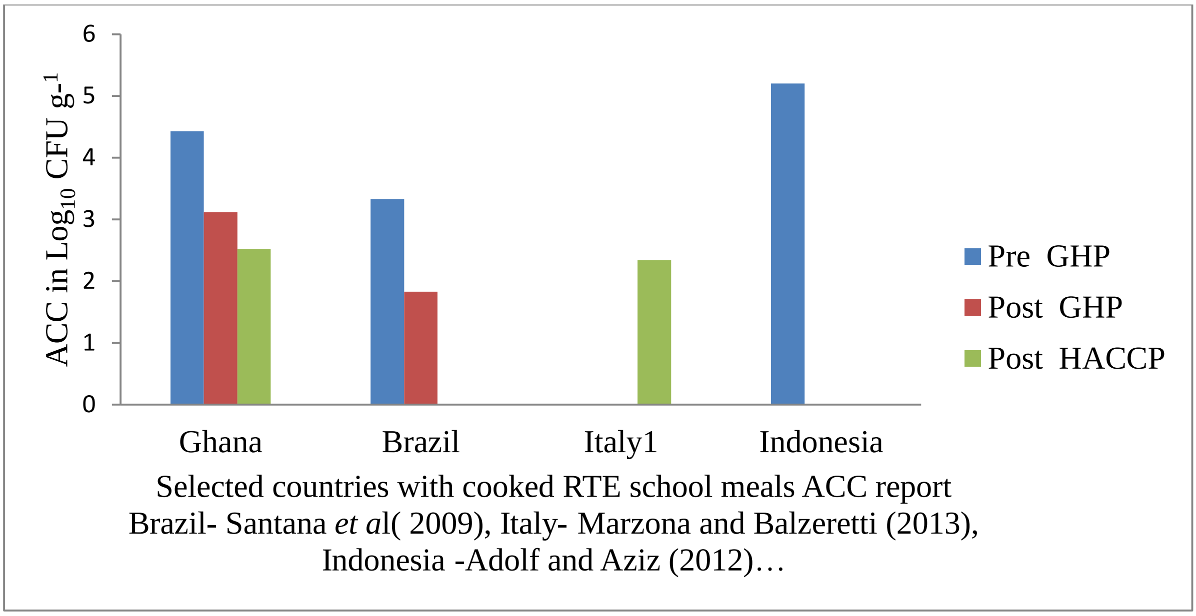


Fig. 21. Comparing ACC load in cooked RTE meals in schools at different stages of hygiene interventions

With ACC and Coliforms although there were significant differences Post HACCP between Pre GHP and Post GHP contaminants using Friedman's test, there was not enough evidence to prove that either GHP or HACCP affected the change at Post hoc. There were however continuous reduction in ACC and coliform levels from Pre GHP to Post HACCP. Santana *et al* (2009) who implemented GHP training in Brazilian schools, Marzona and Balzeretti (2013) who measured microbiological safety of food in Italian Kindergarten and schools with HACCP in place and Adolf and Aziz (2012) from Indonesian schools without any hygiene intervention highlighted on the effect of hygiene practices on the microbiological quality of food (Fig 21). With the mean level of ACC in schools without prior GHP intervention, Ghana and Indonesia recorded high ACC, > 4 $Log_{10}CFUg^{-1}$ in school meals with the exception of Brazil where the mean ACC was < 4 Log. GHP intervention in Ghana and Brazil as shown (Fig. 21) reduced ACC further to <4 Log in Ghana and < 2 Log in Brazil, meeting the national acceptable criteria of 4 $Log_{10}CFUg^{-1}$ in cooked Ready-to-Eat meals. After HACCP Ghanaian school meals had a mean ACC of 2.52 $Log_{10}CFUg^{-1}$ which was similar to the Italian level for ready to eat cooked rice meals reported by Marzona and Balzeratti (2013). The Post HACCP ACC was an improvement on the 5.48±0.97 $Log_{10}CFUg^{-1}$ for cooked RTE macaroni from street foods in Kumasi and 3.3 ±1.80 $Log_{10}CFUg^{-1}$ for 'waakye' (cooked rice and beans) in Accra street foods.

4.5.3 *Effect of HACCP intervention on staff hand hygiene at preparation stage*

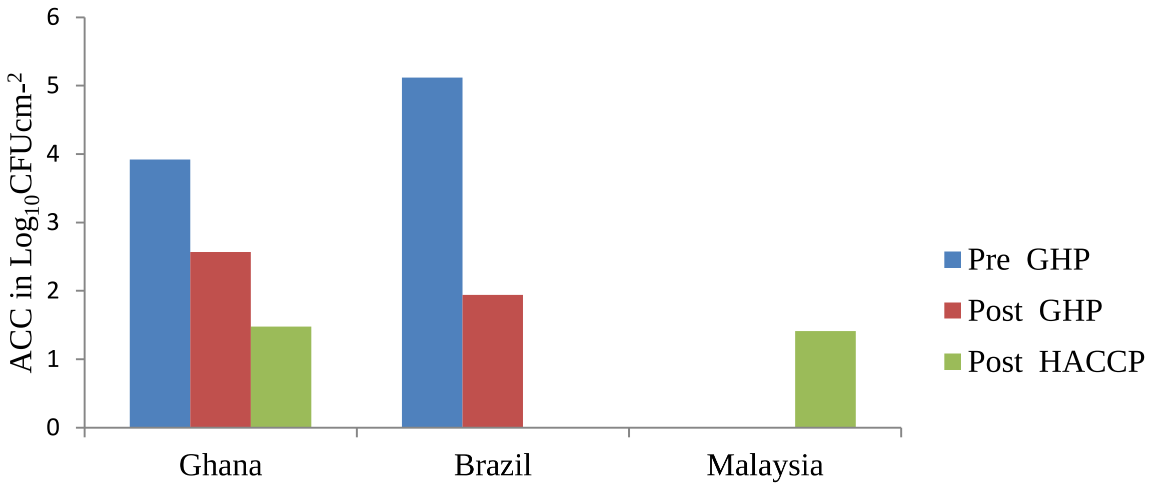
The level of ACC, coliforms, yeast and moulds and *Staphylococcus aureus* on staff hands reduced Post HACCP (Table 43) with yeast and mould and *S. aureus* levels meeting the advisory guideline of 1 $Log_{10}CFUcm^{-2}$ set by the Agriculture, Food and Rural Development of Minitoba (2014) and Sneed *et al* (2004), Marzona and Balzeratti, (2013) and Osimani *et al* (2011) respectively. ACC was only slightly above the 1.3 $Log_{10}CFUcm^{-2}$ guideline by 0.18 Log and coliforms by 0.59 $Log_{10}CFUcm^{-2}$. Staff hand hygiene if poorly managed could directly contaminate cooked food (Bankole *et al*, 2012), hence an improvement also directly affected the quality and safety of cooked Ready-to-Eat meal, jollof rice (Table 42).

Table 43. Microbiological load on staff hands after washing- Post HACCP

	Mean microbiological count on staff hands in $Log_{10}CFUcm^{-2}$				
		ACC (% Satisfactory)	**Coliforms (% Satisfactory)**	**Yeast and moulds (% Satisfactory)**	***S. aureus*** **(% Satisfactory)**
Advisory guidelines		1.3	1	1	1
Treatments	N				
Pre GHP	11	3.92±1.28 0%	4.27±1.68 0%	1.31±1.15 54.5%	2.72±1.08 9.0%
Post GHP	11	2.57±0.88 0%	2.26±1.13 9%	1.09±0.79 54.5%	1.69±1.32 27.3%
Post HACCP	5	1.48±0.33 40.0%	1.59±0.38 0%	0.92±0.28 80.0%	0.93±0.44 40.0%
Chi square (p=0.05)		6.400(0.039)	5.200(0.093)	1.600(0.522)	4.800(0.124)
Post Hoc - 1tailed(p=0.016)	Pre GHP-Post GHP	-1.956(0.027)			
	Pre GHP-Post HACCP	-2.023(0.031)			
	Post GHP-PostHACCP	-1.753(0.063)			

Two schools (40%) had kitchen staff hands meeting the ACC guideline of 1.3 Log10CFUcm^{-2} Post HACCP, although none met this standard at the Pre GHP and Post GHP stage. Regular cleaning of hands with plain soap or antibacterial bar soap and clean water and drying with clean cloth (owned by staff) helped reduce the microbiological contaminants on staff hands. Both GHP and HACCP interventions affected the reduction of enumerated microorganisms on staff hands with ACC levels being significantly reduced [χ^2 (2)=6.400 p=0.039] from Pre intervention levels. There were no significant difference in Pre GHP, Post GHP and Post HACCP levels of coliforms, yeast and moulds and *S. aureus* however Post HACCP means of yeast and mould and *S. aureus* met the advisory guideline of 1 $Log_{10}CFUcm^{-2}$.

Four schools (80%) met the yeast and mould guideline at Post HACCP and two (40%) met that of *S. aureus*. Post Hoc test was conducted for ACC with Wilcoxon's signed rank test with Bonferroni's critical significance. There was not enough evidence to conclude that either GHP or HACCP significantly affected the reduction (p>0.016). However Pre GHP- Post GHP, Z = -1.956 (p=0.027) was much closer to the Bonferroni's critical significant level of p=0.016, hence it seemed that GHP intervention rather than HACCP (p=0.031) affected the significant reduction in ACC levels on staff hands. In Brazil, Santana *et al* (2009) recorded a Post GHP ACC Log reduction of 3.18 from a Pre GHP load of 5.12 $Log_{10}CFU\ cm^{-2}$ (Fig. 21). In Ghana there was a 1.35 Log reduction Post GHP and a Post HACCP log reduction of 2.44 from Pre GHP levels. Mean ACC levels on staff hands in Malaysian schools with HACCP was 1.41 $Log_{10}CFUcm^{-2}$ (Tan *et al* , 2012) which was similar to the Ghanaian Post HACCP mean of 1.48 $Log_{10}CFUcm^{-2}$ (Figure 22).



Schools kitchen staff hand contaminants at different stages of hygiene interventions in different countries
Brazil- Santana *et al* (2009), Malaysia- Tan *et al* (2013)

Fig. 22. Microbiological contaminants on staff hands at different stages of hygiene intervention in three different countries.

Even though there was the use of hand disinfectants in the two countries, plain soap (2 out of 5 schools) and antibacterial bar soaps usage in Ghana seemed to have equally helped in reducing the microbial load to almost acceptable levels to the advisory guideline. School matrons in these 3 schools after introducing HACCP provided anti-bacteria bar soaps for staff handwashing whilst the rest maintained plain bar soaps all from the local market at Post GHP. The 2.44 Log reduction in coliform levels on hands Post HACCP in Ghana (Table 31) could also be said to be satisfactory as the presence of high levels of coliforms could be an indication of the presence of pathogenic bacteria. Yeast and moulds and *S. aureus* levels equally met the acceptable guideline of 1 $Log_{10}CFUcm^{-2}$ Post HACCP. This supports Watutantrige *et al* (2012) who reported a significant reduction in ACC levels ($p \leq 0.05$) for students who washed their hands with soap after toilet to those who did not add soap to their hand washing. Thus in non-aseptic environments like food preparation centers and where economic challenges might not support the provision of resources, clean water, reusable daily cleaned personal hand towels and affordable plain soaps hygienically stored could equally help reduce the risk of food contamination with enteric pathogenic bacteria via staff hands.

4.5.4. *Effect of HACCP intervention on cleanliness of food contact surfaces*

Plate 38&39. Washed pans and cups upturned after washing for effective draining and to avoid pest droppings

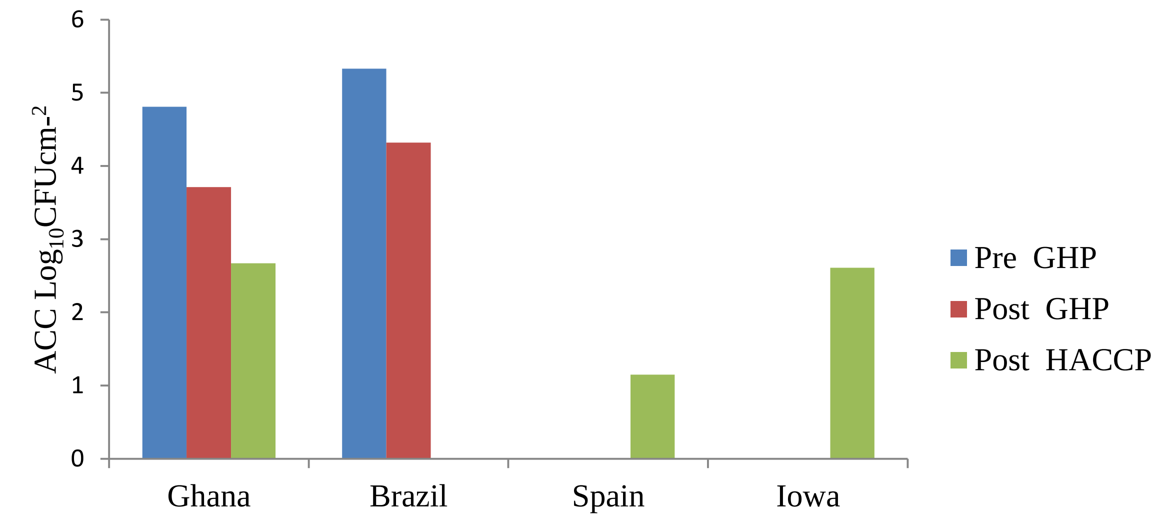
Post HACCP practices included upturning cleaned utensils for effective drying and to avoid the risk of contamination from insects and pest droppings (Plate 38, 39). Hygienic control of cleaning sponges by pantry staff and use of clean water at 3 different stages of rinsing, detergent washing and rinsing. Post HACCP ACC, coliforms, yeast and mould on utensils reduced from Pre GHP to Post HACCP with log reductions of 2.14, 2.36 and 1.43 $Log_{10}CFUcm^{-2}$ respectively (Table 44). The reductions in ACC and yeast and mould levels on utensils were significantly different. ACC was [χ^2 (2) =10.00 p=0.024] and yeast and mould was [χ^2 (2) =7.600 p=0.024], although that of coliforms were not significantly different (p>0.05) using Friedman's Test (Table 33). Post Hoc analysis was conducted using Wilcoxon's signed rank test with Bonferroni's critical significance p=0.016 to determine which intervention had a significant effect on the reduced ACC, yeast and mould levels on equipment after cleaning. There was enough evidence that GHP intervention significantly reduced and effected the improvement, Post GHP - Pre GHP ACC was Z=-2.578; p=0.003, and yeast and mould was Z=-2.490; p=0.005.

Table 44. Microbial Load on food contact surfaces Post HACCP

		Mean microbiological count in $Log_{10}CFUcm^{-2}$					
		ACC (% satisfactory)	**Mini-mum Maxi-mum**	**Coliforms (% satisfactory)**	**Mini mum-Maxi mum**	**Yeast and moulds (% satisfactory)**	**Mini mum-Maxi mum**
Advisory guidelines		1.3		1		1	
Treatments	Number of schools						
Pre GHP	11	4.94±1.24 (0.0%)	3.08-6.60	4.93±1.24 (0.0%)	3.00-7.04	2.73±0.58 (0.0%)	1.56-3.92
Post GHP	11	3.37±0.81 (0.0%)	2.39-4.59	3.18±1.15 (0.0%)	1.78-5.27	1.97±0.68 (22.2%)	1.16-2.96
Post HACCP	5	2.67±0.38 (11.1%)	2.04-2.99	2.28±0.54 (11.1%)	1.65-2.71	1.68±0.34 (17.0%)	1.16-2.01
Chi square (p=0.05)		10.00(0.001)		5.200(0.093)		7.600(0.024)	
Post Hoc (1tailed)	Pre GHP-Post GHP	-2.578(0.003)				-2.490(0.005)	
	Pre GHP-Post HACCP	-2.023(0.031)				-2.023(0.031)	
	Post GHP-Post HACCP	-2.023(0.031)				-0.647(0.313)	

Two equipment (11.1%) from the schools met the ACC and coliform advisory standard Post HACCP intervention and 3 (17%) for yeast and mould levels. Cleaning was done with first rinsing, cleaning with water in a basin (mostly not heated) with detergents and thirdly rinsing and leaving to air dry inverted (Plate 40 and 41) without sanitizing. Sponges were cleaned and air dried after work and staff were trained not to leave sponge on the floor during work. This reduced the microbial levels further although the advisory levels could not be met. These advisory guidelines were used by schools that had sanitizing stages in their cleaning procedure with HACCP. Ghana after GHP intervention recorded mean ACC of 3.37 Log_{10} $CFUcm^{-2}$

which was lower than the 4.42 $Log_{10}CFUcm^{-2}$ ACC mean on utensil in Brazilian schools although Brazil had a higher mean (5.33 Log) at Pre GHP stage. After HACCP there was further reduction in mean ACC load to 2.67 $Log_{10}CFUcm^{-2}$ which was similar to the 2.61 $Log_{10}CFUcm^{-2}$ in Iowa (Sneed *et al* 2004) but higher than that of Spanish schools that had 1.15 $Log_{10}CFUcm^{-2}$ (Rodrguez-Caturla, 2012) both with HACCP in place (Fig. 23), and with the use of disinfection stage in their cleaning procedure which was contrary to the Ghanaian condition. Mensah *et al* (2002) in their work on street foods in Accra- the capital city of Ghana added that soap and water reduced microbiological load on food contact surfaces and hence directly affected food quality. Sneed *et al* (2004) highlighted the need for attention to be given to training and supervision to ensure appropriate cleaning and sanitation procedures to reduce or eliminate cross-contamination as only two facilities out of 40 met the standards for all five surfaces on three test conducted in their work in Iowa.



Brazil (Santana *et al* 2009), Spain (Rodrguez-Caturla, 2012), Iowa (Sneed *et al* 2004)

Fig. 23. Level of utensils contaminants at different hygiene intervention stages from different schools and countries

Seventy five percent (75%) of the sampled facilities in Iowa had cutting boards failing to meet the 1.3 $Log_{10}CFUcm^{-2}$ guideline for ACC. Rodriguez- curtalar (2012) reported on absence of food pathogens in ready to eat food in Spanish school canteens but highlighted the need for special attention to particular kitchen equipment (taps and cutting boards). Cutting boards were not in use in the Ghanaian schools as most vegetables and fish were prepared by hand and meat and poultry came already cut into desired pieces from the suppliers or market. This supports Ababio and Adi's (2012) report on food hygiene awareness and practices of food handlers in Kumasi Metropolis. In Ghana after HACCP intervention, knives and grinders were the equipment that still had some of the highest ACC load. Hence there was the need for special attention with these. Ladles and pans which came directly in contact with cooked ready to eat meals required good cleaning and storage practices to avoid contamination risk. Sanitizing stage could further reduce the microbiological contaminant levels although products were not readily available on the market and also were not economically viable.

4.5.5 *Summary*

Table 45. Effect of GHP and HACCP intervention on schools hygiene audit scores

Schools	Pre GHP audit score	Pre GHP audit category	Post HACCP audit Score	Post HACCP audit category	p(1 tailed)
OO2	6.8	Medium	9.6	Excellent	2.023(0.031)
OO3	5.8	Medium	9.4	Excellent	
OO7	8.4	Good	8.9	Good	
O19	7.1	Good	9.5	Excellent	
O26	8.2	Good	9.7	Excellent	

The overall hygiene score of the schools Post HACCP improved. Four schools moved to excellent hygiene category, with one Good hygiene school remaining in the same category but increasing in scores. The increase in scores Post HACCP was significantly different (p=0.031) from Pre GHP scores with the use of Wilcoxon's signed rank test (Table 45). Although most aspects of facility design on the audit questionnaire (Appendix 1) in the schools remained the same, condition of hygiene and cleanliness and availability of suitable products for personal hygiene improved. With utensils and equipment maintenance, system of daily checks, recording and report of breakages and maintenance was created. In the absence of hot holding equipment (Appendix 8), food temperature probes were provided for monitoring and maintenance of effective food temperature with effective time monitoring. Personal hygiene greatly improved with staff encouraged to avoid jewellery during preparation and service, cleanliness of uniforms on daily basis, use of hair covers and good hand washing procedure. Effective control of staff health and report of infectious diseases was established with matron's records available to manage this. With quality of raw and ready to eat food, records were created and staff trained on in-process checks including, staff hygiene practices, food processing and quality control at receiving stage with related records provided. Shelf life integrity of incoming goods was stressed at both the procurement office during inspection and at staff training. Food temperature, food service time, microbiological contaminants in cooked Ready-to-Eat meal, staff hand hygiene and microbiological contaminants on food contact surfaces had continuous improvement Post HACCP intervention. Post HACCP food temperature [χ^2 (2)=7.600;p=0.015], Post HACCP jollof; ACC [χ^2 (2)=6.400;p=0.039], jollof Coliforms [χ^2 (2)=9.58;p=0.002] and *S. aureus* [χ^2(2)=7.54;p=0.037], Post HACCP staff hands ACC [χ^2 (2)=6.40;p=0.039], Post HACCP Utensils ACC [χ^2 (2)=10.00;p=0.001] and yeast and moulds [χ^2 (2)=7.600;p=0.024] were significantly different from the Pre and Post GHP levels using Friedman's Test for non-parametric repeated measures. All 5 schools food temperature met the agreed hot holding food temperature of 63℃ during service and an hour between after cooking and students dining time, all ACC and yeast and mould levels in jollof for all 5 schools met the GS 955:2013 of Ghana Standards Authority (2013) acceptable levels for cooked and ready to eat rice and related meals. Whilst 40%, 60% and 80% of the schools had acceptable levels of coliforms, *B. cereus*, and *S. aureus* in rice at Post HACCP intervention. All yeast and mould and *S. aureus* levels on staff hands met the advisory guideline for food contact surfaces set by the Agriculture, Food and Rural Development for Manitoba (2014) and Sneed *et al* (2004), Santana *et al* (2009), Marzona and Balzeratti (2013) and Rodriguez-Caturla, (2012) respectively. Post HACCP food holding time, yeast and mould and *Bacillus cereus* in jollof rice, total coliforms, yeast and mould and *S. aureus* on staff hands and total colforms on utensil after cleaning were not significantly different ($p>0.05$) from the Pre GHP and Post GHP levels. However there were continuous improvement in all of them with most meeting the national acceptable standards for food or advisory guidelines for food contact surfaces.

5.0 GENERAL DISCUSSION

This section discusses highlighted research outcomes in relation to literature with direct link to the national Ghanaian situation and proposes solutions for improved food safety systems in the food industry.

5.1 Challenges and cost of foodborne infections in Ghana

It is believed that the existence of other major concerns including food security, political instability, communicable diseases and eradication of poverty dominate governments agenda hence food safety remain a low priority among their concerns. (FAO/WHO, 2005a). Foodborne diseases however contribute hugely to human morbidity and mortality internationally. The overall cost incurred when there is foodborne infection or outbreak is huge as productivity is reduced and huge sums of money are used in the treatment and cure for the affected persons. The demise of consumers and negative popularity for the food industry and agencies responsible for surveillance and control remain challenges for governments.

5.1.1 Cost of Foodborne Infections in Ghana

Foodborne infections affect 625,000 people annually (based on 2010 statistics) in Ghana, (MoFA/WorldBank, 2007), with 297,104 hospitalisations (FDA, 2008) causing 90,692 deaths. The cost incurred by the government annually is reported to be 69 million US Dollars (MoFA/WorldBank. 2007) which could have increased after 11 years. Fifty two percent (52%) of the 180 students sampled from 45 SHSs in the Ashanti Region of Ghana reported to have experienced FBDs in school. One (1) in every 2 students in SHSs in Ashanti Region experienced at least one FBD per school term (3-4 months) as per student's report. Minimum infection rate reported was thus 3 times per year. This report is higher that the MoFA/WorldBank (2007) report of 1 in every 40 Ghanaian experiencing FBD annually. If adolescents with much vigour report such rates, then the worse could be expected among the young, the elderly and immunocompromised in the society. Affected students reported to have spent between 1.00 to >50.00 Ghana Cedies (GhC) on medication with 10% spending between GHC 30.0 - > 50.0. Cost was borne by the National Insurance Scheme, parents, school or the students themselves. Foodborne infection is a national issue that requires redress.

5.1.2 Productivity losses

Loss to productivity in the country due to FBDs was reported to be 594,279 productive days (Odame-Darkwa, 2008). Assuming infection rate has remained the same from 2006 to 2015, the cost to lost productivity alone could thus be GhC 33,279,624.00 (based on 2015 minimum wage in Ghana) or £ 5,464,634.48 GBPS or $ 8,533,236.92 USD (based on August 2015 exchange rate). This is a huge cost and cannot be underestimated. Other losses incurred by the sick for medication (treatment), laboratory charges, care if needed, investigation into causes among others have not been included in this estimation. Apart from gastroenteritis, there are other food related health problems like allergy and chemical food poisoning that have also not been considered. Out of the 52% of students who reported to have experienced FBDs in school, 49% reported to have spent between 1 and 5 days off school or active academic work. Twelve percent (12 %) of the students had been absent from active academic work for as long as 5 days due to FBD indicating possible overall losses to the country.

5.1.3 Low reporting culture and illusion of safety

Low reporting culture of foodborne infections and lack of regular surveillance may create an illusion of safety for food managers however food safety hazards may have short and or protracted health effects on consumers. Kitchen matrons as reported by Afoakwa (2005) did not consider their current practices as a risk to food safety. Others during auditing added that they also eat some of the food and wouldn’t subject the food to conditions that would put themselves at risk or the students. Thus lack of awareness of the possible causes of foodborne infections may also prevent consumers and food handlers from linking their poor health to food. The media has been the major source of food poisoning information in Ghana and most especially for cases from schools in the country. Reporting rate is low and information on aetiology is limited. The establishment of information systems between the health sector, laboratories and surveillance agencies as practised in the United States could equally help in the monitoring and control of foodborne infections. There is the need to continue educating and creating awareness among consumers to demand best practices from food service providers. Increasing report on poor hygiene practices after inspection, foodborne infections and outbreaks, the causes and naming and shaming by appropriate institutions and making public such reports could go a long way to push the food industry to want to adopt available good practices. Out of the 52% of students who reported on the affirmative on experiencing FBD in SHSs in Ashanti Region only 21% had reported to health facilities for confirmation whilst 31 percent only blamed food they had eaten for the cause although all reported to have spent some amount of money on medication. There was however an improvement on FBD awareness as previous report by Tortoe *et al* (2013) and Tomlins *et al* (2002) indicated that some consumers did not associate food with illness whilst over 90% of the students were aware of foodborne infections and symptoms from schools in Ashanti Region. Self-medication with the use of off-counter drugs was also an issue as indicated by both students and kitchen staff report in this research. People's ability to get off counter drugs for treatment meant foodborne infection and poisoning information might not reach the appropriate health centers for treatment and possible investigation and documentation. Thus lack of surveillance and reporting could create the illusion that current practices are safe which in actual sense are not.

5.2 Challenges in Ghana- Senior High Schools in Ashanti Region case

In the development of school infrastructure, kitchens and their needed ancillary rooms including areas for storage, staff changing rooms and adequate toilets in addition to preparation, service and dining areas with adequate ventilation need to be considered. Effective drainage systems, washable walls, doors and windows equally require consideration. Properly enclosed kitchens towards effective access control is required. Available and adequate lighting, hand washing basins, shelves and monitoring devices are required. The planning of infrastructure for schools require a complete knowledge of the requirement of kitchen design with hygiene in mind to compliment other structures raised in schools. Kitchens design should not be of least priority or secondary concern to headmasters and government contracted builders.

5.2.1 Infrastructure and facility design

Most kitchens were designed without hygiene in mind. From building fabric, enclosures, drains to roofing required improvement in most schools. Kitchens had limited space for storage and some matrons stored food in their offices, toilets were limited or absent and staff lacked changing rooms. None of the schools who had staff changing rooms provided lockers for their staff personal items thus items were not properly kept and food could be stored in these areas creating pest ingress and food contamination. There was the need for school management and matrons to collaborate on improving standards. The lack of the provision of handwashing basins and detergents for hand washing in the kitchens and toilets for instance were serious breaches in hygiene which could be corrected if the awareness of the importance of hand hygiene was available.

5.2.2 Utilities and equipment maintenance

Although matrons reported of external auditors checking on their food and equipment usage in the schools, maintenance culture was not evident in the schools as broken down milling machines remained unrepaired and schools depended on other public sources for milling for food ingredients. Cleaning of milling machines were evidently not supervised as equipment and environment were mostly not cleaned and operators seemed to be on their own even though they had no hygiene training. Cleaning of kitchen utensils, kitchen environment were not properly scheduled and there were no documented procedures for effective cleaning practices or training. Supervision was also not evident on these. Kitchens procedures required standardisation instead of the current operation from experience and luck (Taylor, 2001). Matrons and assistant matrons required spelt out responsibilities to cover every aspect of their work for effective supervision and control. Currently supervisors were highly production oriented with limited food hygiene and safety control motivation.

5.2.3 Employee hygiene

Food Laws in Ghana and the United Kingdom have similar requirement on the provision for the sale food that is not injurious to health. The preparation or manufacturing of food for sale is required to be under supervision in Section 6 of the 1992 PNDCL 305B, and the Public Health Act of Ghana, Act 851 of Ghana (FDA, 2012). The Law (Prohibited Acts 106) requires persons in supervision to be of the appropriate qualification and knowledge to ensure the purity and wholesomeness of food. Training of subordinates to commensurate with their responsibilities is not mentioned. Whilst there is further expatiation on the requirement of staff hygiene training in Chapter VIII on Personal Hygiene, Annex II of Regulation (EC) 852/2004, the Law in Ghana has limited information on this. The Law in Ghana hence requires further information on the requirements for food handlers in terms of hygiene. Kitchen staff in schools required training which was not evident whilst 31.1% of matrons reported not to have had any hygiene training although in supervisory roles. This limited their hygiene knowledge and hence their ability to identify risks and improve on them. Over 90% of cooks and pantry men had no hygiene training and the only on job training some of the staff (69%) reported to have had was during induction. It is the responsibility of those in supervisory role to train staff on requisite hygiene practices if management cannot afford external training. Training should however commensurate with the roles of personnel. This was not evident, as cleaning staff left sponges on the floor, staff wore jewellery and lack of soap on toilet for instance was not a concern for either staff or supervisors. Infectious disease including vomiting and diarrhoea was not properly managed due to absence of awareness and policies on proper handling of such situations by management.

5.2.4 Raw material and ready to eat meals quality

Schools hugely depended on the procurement plan set by the Ghanaian government. The schools procurement unit handled suppliers of raw materials and issued to kitchens per demand. Most of the agricultural produce (maize, rice, beans and groundnuts) came with physical contaminants including stones, wood, insects and agro chemicals for pest control. Although staff had internal control measures including sorting, washing, winnowing and sieving, students still complained hugely of stones and insects in food. These laborious tasks affected other cleaning practices of the kitchen staff as staff spent hours improving on the quality of the raw materials before cooking. Matrons also complained of insecticides in food supplied to them which could pass on into cooked food if not detected and had to be handpicked. The food chain in the country requires control and improvement through continuous training and awareness programmes. Matrons and procurement units associations could also put forward the grievances from students to their suppliers and school heads for quality improvement. The time and temperature of cooked food required monitoring and control as well as currently most processes and food service providers had no monitoring devices to control these. In the absence of monitoring devices like temperature probes, effective time monitoring could effectively help in attaining the right food holding temperatures for meals as indicated by Dablool *et al* (2014). Suitable thermal controlled containments could also be provided for schools for dishing cooked meals in place of the aluminium and stainless pans in use. Evidence of control is also required under reasonable precaution and practice and for due diligence. Procurement officers training in food safety and inspection to improve on their and practices during raw material sourcing and receiving. Their document on good receiving lacked food expiration dates check confirmation which is a safety issue. Some procurement staff responded during interview that they checked expiration date before receiving goods but were not documenting. This was not a standard operating procedure as some matrons also reported they had to return certain products as they had expired to the issuing officer.

5.2.5 Process/service flow and quality control

Although most food prepared for sale and service are cooked ready to eat, there was no evidence of temperature and time control. Cooked food route mostly crossed preparation, washing and storage areas instead of moving directly to service and dining rooms. Thus even those schools who had L or U shaped kitchens had not designed the processing with hygiene and cross contamination control in mind. The assumption that cooked food had to be covered to prevent contamination by flies was high but microbiological contaminants and multiplication in food was new to most kitchen staff. One matron was using a term with her staff in their local dialect 'ehyea na edɛ', that is to day it taste better when hot. Keeping food hot was known but absence of monitoring devices and containments meant food within the danger zone was considered acceptable, and food holding times were prolonged post cooking. There is the need for legal demand for integrated food safety management systems in the local food industries and food service establishments in Ghana as currently most processing are done without the necessary evidence of control-documentation. Treatment and control of drinking water was not evident in the schools and most schools depended or complimented main pipe supplies with bore holes and other external tanker suppliers.

5.3 Way forward

The mandatory requirement for the use of integrated food safety management systems across the food industry in Ghana including both public and private owned businesses is the way forward. There is enough evidence in both literature and this research conducted in SHS in the Ashanti Region of Ghana that introduction of food safety management systems creates awareness, improves risk management and positively affect food safety. Management commitment, well-educated/trained personnel, available resources and external pressure from government and consumers are the major key areas that would push the local food industry into good practices (Panisello and Quantick, 2001). Proper registration, premises inspection before approval, qualified personnel with training that commensurate with their activities, available and suitable facilities and resources are to be certified before approval for service in both institutional and commercial settings.

5.3.1 Management commitment

Out of the 12 schools visited for GHP intervention, only one headmaster opted out and during HACCP intervention, most heads of intuitions were happy to take part. Out of the 45 school matrons who responded to the questionnaires, only two percent reported lack of interest as the reason for not wanting to adopt HACCP and adding that they had not had any food poisoning case yet. It was evident that if heads and matrons had the technical assistance, and awareness they were likely to accept the challenge of improving food safety in their schools. Increased law enforcement and detailed information on the legal requirements for food establishment being made available to managers in the food service industry could help improve on current practices.

5.3.2 External pressure requirement

The combined effort of legislation, surveillance and enforcement by the Environmental and Health Protection agencies, Food and Drugs Authority and laboratory services and the media in reporting and following through the causes and effect of foodborne diseases on consumers is required. Consumer groups and other stakeholder’s awareness creation will also raise the requirements for better standards from the food industry.

5.3.3 Minimum requirement and other certification bodies

Whilst the Food Standards Authority and Food and Drugs Authority are the main state agencies responsible for the provision of standards for the food industry, there is currently no documented system for operation for the food industry in Ghana that could help food industries especially locally owned to operate according to international standards. Ghana is among the Codex Alimentarius member countries and hence this would be considered the minimum standard of operation for the food industry. There is the need for other certifying bodies to develop standards that the industries could operate with thus enhancing auditing and compliance and promoting competitiveness in the industry.

5.3.4 Personnel education and training and staff hygiene resources availability

The development of training programmes by government and approved private agencies for food handlers with continuous reforcement training and upgrade requirement as practiced in the food industry in the United Kingdom is required in Ghana. Training must be effective and must commensurate with staff roles and responsibilities. The legal duty of ensuring that personal are trained and operating according to established standards becomes business owners and managers responsibility with penalties for noncompliance.

The academic qualification for matrons to be in supervisory position require a review to include food safety control and management. This will equip matrons and motivate them to develop acceptable standards in their kitchen. Matrons equally need to be equipped to initiate internal training and effective supervision and to document the detailed individual roles and responsibilities of both assistant matrons, team leaders, cooks and pantry men in their kitchen. The provision of protective uniforms and hair covers and suitable shoes for kitchen staff is required to promote hygiene. It was evident that although most schools provided these they were not replaced when worn out. Kitchen staff therefore wore new uniforms by sewing new ones themselves which others could not afford. Some matrons used internally generated funds to provide new uniforms and aprons for staff. There was therefore the need to establish appropriate policies on maintaining staff hygiene in the kitchens.

5.3.5 Extended research focus

Work on the other types of food hazards; chemical, physical and allergens and their effects across the food chain including institutional and commercial catering is required to help in the development of national food safety objectives in the country. This will also help in developing appropriate acceptable limits for identified food hazards towards effective decisions on control measures for the food industry.

6. CONCLUSIONS

- Sixty percent (60%) of Senior Secondary Schools in Ashanti Region of Ghana provided 3 meals (breakfast, lunch and supper) to between 1000 – 3000 students per day.
- Approximately 52% of the 180 students sampled from the Ashanti Region had experienced FBDs during their 1-2 years life in school with 9% reporting to have experienced this over 3 times during a term.
- Foodborne diseases affected students academically and economically as students could stay up to 5 days from active academic work and could spend up to GHC 50.00 on medication during such incidence.
- Stones and insects in meals provided were major food contamination concerns for students followed by human hair and metals.
- Food allergy/intolerance was prominent in the schools as 56% of the students reported to suffer from related symptoms although only 37% had reported and 24% were given alternative meals. Sufferers were more likely to avoid these foods when served in schools.
- Foodborne diseases and food allergy/intolerance did not significantly affect level of dining hall attendance by students as 77% of the sampled students visited the dining hall all the time or mostly. Only 22.8% reported to visit sometimes which was lower than the over 50% allergy sufferers.
- Those students who only sometimes ate school meals and used other sources of meals were more likely to spend more on medication than those who ate school meals all the time. School meals could be safer with less cost to FBDs when access to other sources of meals are controlled.
- Whilst kitchen hygiene standards in all the Lincolnshire schools were of a high standard as per check list only 17.8% of the Ashanti Region schools were within the good

hygiene category, 73.3% were in medium hygiene category and 8.9% were in poor hygiene category.

- Poor standards in schools in Ashanti Region was reflected in low test scores in food and personal hygiene requirement, food temperature and time control and the microbiological contamination levels in jollof rice and swabs from staff hands and kitchen utensils with cooked food exceeding national acceptable criteria GS 955: 2013 and international advisory guidelines respectively.
- *Bacillus cereus* could be a potential food poisoning bacteria in secondary schools as most meals had rice as the main carbohydrate component among others including 'kenkey', 'banku', yam and 'gari. Hence effective food temperature and time control was required to avoid *B. cereus* food poisoning. *Salmonella* spp was not detected in groundnut soup and coagulase negative rather than coagulase positive *S. aureus* were predominant in food.
- Staff food hygiene training was not a culture in the Ashanti Region schools and none of the schools had documented Food Safety Management system in place. Pest control, staff personal hygiene including hand washing, infectious disease management and jewellery usage during food preparation, lack of cleaning procedure and supervision were evident in most schools.
- Although matrons or kitchen managers were available in both Lincolnshire and Ashanti Region schools, thus satisfying the legal requirement of the 1990 Food Safety Act in UK and 1992 Food and Drugs Law and the 2012 Public Health Act 851 in Ghana for supervision in food establishments, 31.1% of the 45 matrons in Ashanti Region did not have hygiene qualification.
- Economic conditions in the two countries affected hygiene standards as both infrastructure (kitchen design, toilets for staff, staff changing rooms), facilities (food

storage areas, cold storage, and hand washing resources) availability and status varied with 80% of the SHS kitchens in Ashanti Region not having suitable toilet facilities (availability, proximity and maintenance).

- Good Hygiene Practices (GHP) intervention in the forms of staff training significantly improved Post GHP staff food hygiene awareness and personal hygiene requirement test scores, food hot holding temperature at service, and microbiological quality (ACC, Coliforms, *S. aureus*). Staff hands microbiological contaminants (ACC, and Coliforms) after washing, ACC, and coliforms on grinders, knives and ladles significantly ($p \leq 0.05$) reduced Post GHP. Yeast and mould on knives and grinders also significantly reduced.
- Personal hygiene requirement scores significantly and negatively correlated with *S. aureus* in jollof rice ($r = -0.682$, $p = 0.02$), thus as hygiene improved *S. aureus* contamination in RTE food reduced.
- HACCP brought about an improvement on the GHP intervention results with Post HACCP ACC and coliforms in jollof rice significantly reduced ($p = 0.039$, $p = 0.002$ respectively) and all yeast and mould and *S. aureus* in the schools meals meeting the national microbiological criteria in cooked RTE food. Food temperature also significantly improved Post HACCP ($p = 0.008$). ACC on staff hands and food contact surfaces and yeast and moulds on food contact surfaces reduced significantly ($p < 0.05$) Post HACCP.
- Post HACCP food temperature, ACC in RTE meal, on staff hands and food contact surfaces were comparable to other international (Brazil, Malaysia, Spain and Iowa) authors report from schools with HACCP and available infrastructure and standard facilities including hand antiseptics and disinfection stage in their cleaning procedure. Thus regular usage of plain soap, and the use of clean water and detergent with hygienically stored sponges and utensil equally improved cleanliness.

- There was enough evidence with Wilcoxon's signed rank test (Post GHP) and Friedman's T test (Post HACCP) that change had taken place after the two interventions. Post Hoc analysis using Bonferroni's critical significant correction indicated that GHP effected the significant improvement in the Pre intervention results.
- In the absence of sophisticated equipment and state of the art technology, the minimum requirement of GHP and applied HACCP principles were successful in the sampled schools in improving food safety in Ghana.

7. RECOMMENDATIONS FOR FURTHER WORK

7.1 Research

- A study of current food safety auditing objectives and visiting frequencies to institutional food services by relevant state agencies in line with Codex Alimentarius requirements towards the development of appropriate industrial operating manuals for food services in the country for effective and targeted food control.
- The combined effort on awareness creation through workshop provision for procurement officers, suppliers and school management to facilitate effective food quality control and traceability in the food chain.
- National food allergy study towards identifying types of sufferers, kind of foods causing allergy and indigenous methods of management and control towards effective health management in the country and available information for the food industry on consumer information on food labels.
- An investigation into the importance of the presence of food vendors on institutional premises, their contributing effects on foodborne diseases among consumers and proposed methods of control towards effective policies on sale of food on school premises.
- A thorough study on available Food Laws in the country including the Public Health Act of Ghana (2012) and individual Metropolitan and District Assembly rules in conjunction with other international Food Laws towards proposals for amendment to enhance food safety monitoring and control in Ghana.

7.2 ***Recommendation for school canteens***

- Kitchen staff training on personal hygiene requirements and process control which is absent in all the schools requires prompt attention as acquisition of knowledge translated into safe food for students.
- Cleaning practices are below standard, poorly supervised, unscheduled and limited to utensils and few areas of the kitchen. This requires an immediate change in cleaning culture.
- Matrons in charge of food safety in schools require training programmes to upgrade their existing knowledge on food safety and good hygiene practices and the legal requirements of their role including effective supervision. Current roles are predominantly production focussed.
- Although matrons had the help of assistant matrons however their respective roles and responsibilities are not spelt out. This brought about friction and lack of awareness in how other responsibilities like cleaning, staff monitoring could be managed. Matrons' leadership skills in scheduling work and monitoring of the kitchen needed improvement.
- Absence of consumables like hand washing soap, clean towels or disposables for hand wiping on toilets and lack of toilets for kitchens staff is a serious issue that prevents staff from maintaining good practices and could be changed by matrons and school management ensuring that water is readily available with soap near the places of convenience or before entrance into the kitchens to ensure staff readily wash their hands.
- There is the need for pest and insect control programmes across the schools. There are no operational organisations that schools could depend on for this good measure in the region and self-management brought about food safety risks matrons are conscious

about. Making available state operating systems that both public and private establishments could use for this service would be very helpful.

- There is the need for regular surveillance and routine monitoring by external bodies on food hygiene practices in the school kitchens as currently auditing in school kitchens by the state agencies only involved equipment and resource usage rather than food safety. The environmental health officers also focused on staff health in connection with infectious disease control only.

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APPENDICES

1. Audit questionnaire

Auditing Template to investigate availability of food safety management systems and food safety practices in school kitchens in UK as a comparative study to Ghanaian school kitchens

School demographics

1. School Number -------------------------------------
2. School District [ ] Urban [ ] Rural
3. Please indicate your type of industry with a tick
   1[ ] Government 2[ ] Private 3[ ] Government/Private partnership
4. Years of existence 1 [ ] 1-10 years2 [ ] 11-20 years 3 [ ] 21 – 30 years 4 [ ] >40 years
5. Number of kitchen staff 1[ ] 1-10 2 [ ] 11-20 3[ ] 21-30 4[ ] 31-40 5[ ] > 40
6. Type of kitchen 1 [ ] Centralised kitchen 2[ ] Onsite kitchen 3 [ ] Both
7. Type of meals provided. Please tick as many as are applicable
   1[ ] Hot meals 2[ ] Cold meals 3[ ] Both

Check List

Part 1. Facility-design (layout)	-Suitable localization: area free of unsanitary conditions, absence of trash, old objects, pests, insects, animals, rodents	(2) Yes	(0) No	(2) NA
	-Access suitable: direct and independent, not the same to other uses (house)	(2) Yes	(0) No	(2) NA
	- Suitable floors;			
	1.3.1. Smooth finish, impermeable , washable, light colour and good maintenance	(1)Yes	(0)No	(1)NA
	1.3.2. In perfect conditions of cleanliness and covered drains	(1)Yes	(0)No	(1)NA
	– Ceiling/suitable roof light colour and good maintenance	(1)Yes	(0)No	(1)NA
		(1) Yes	(0)No	(1)NA

In perfect conditions of cleanliness

1.5- Wall/suitable division

1.5.1 Smooth finish, impermeable, washable, light colour and good maintenance	(1)Yes	(0)No	(1)NA
1.5.2 In perfect condition of cleanliness	(1)Yes	(0)No	(1)NA
1.6- Suitable doors and windows smooth surface, impermeable, washable, easy to clean and good maintenance	(1)Yes	(0)No	(1)NA
1.7 Presence of the protection against insects and rodents	(4)Yes	(0)No	(4)NA
1.8 Suitable illumination to development activity, without overshadow, strong reflection, shadows and excessive contrast	1(Yes)	(0)No	(1)NA
1.9 Suitable ventilation, comfort of temperature and free environment of yeast, gas, smoke and steam abridgement	(1)Yes	(0)No	(1)NA
1.10 Suitable toilet facilities			
1.10.1 Separate by gender, with toilet and washbasin in suitable number, without communication with work room	(2)Yes	(0)N0	(2)NA
1.10.2 Perfect conditions of hygiene and cleanliness: with suitable products for hands antiseptic	(4)Yes	(0)No	(4)NA
1.11- Suitable cloakroom/staff changing room			
1.11.1. Separate by gender, with enough-room, per area for a locker for employee, bath or shower	(1)Yes	(0)No	(1)NA
1.11.2. Perfect condition of hygiene and cleanliness and organization with suitable products of personal hygiene	(2)Yes	(0)No	(2)NA
1.12. Washbasin in the manipulation area			
1.12.1 Presence of washbasin with tap water in strategic position concern to production flow and service	(2)Yes	(0)No	(2)NA
	(4)Yes	(0)No	(4)NA

	1.12.2. Perfect conditions of hygiene and cleanliness with soap, scrubbing brush for hands, paper towel			
	1.13 Supply pure water. Connected to public system or certified by official form (6 months validity)	(8)Yes	(0)No	(8)NA
	1.14 Water tank/storage and hydraulics facilities	(4)Yes	(0)No	(4)NA
	1.14.1 With suitable volume and pressure, with lid and in good maintenance, free of leaks, infiltration and peeling	(8)Yes	(0)No	(8)NA
	1.14.2 Perfect conditions of hygiene and cleanliness. Free of waste on the surface or in the depths			
	1.15 Suitable destination of the waste	(4)Yes	(0)No	(4)NA
	1.15.1 Domestic trash inside the facility in continent with lid, clean and sanitized regularly	(2)Yes	(0)No	(2)NA
	1.15.5 Other waste (solid and gassy) proper treatment and lunched without causing any damage to the neighborhood			
Part 2 Utensils and equipment maintenance	2.1 Equipment /proper machines	(2)Yes	(0)No	(2)NA
	2.1.1 Equipment with smooth surface, easy to clean and disinfect. Good maintenance and working order	(4)Yes	(0)No	(4)NA
	2.1.2 Perfect condition of cleanliness			
	2.2 Suitable utensils	(2)Yes	(0)No	(2)NA
	2.2.1 Smooth utensils, in non-infected material with size and shape that allows easy cleaning. In good maintenance	(4)Yes	(0)No	(4)NA
	2.2.2 Perfect condition of cleanliness			
	2.3 Furniture (tables, benches, windows)	(2)Yes	(0)No	(2)NA
	2.3.1 In sufficient number, resistant, smooth and impermeable material, with integrity surface (without cracks and wrinkles) and in good maintenance	(4)Yes	(0)No	(4)NA

	2.3.2 Perfect condition of cleanliness			
	2.4 Equipment for protection and holding in proper refrigeration/hot holding	(4)Yes	(0)No	(4)NA
	2.4.1 Equipment with proper quality, smooth parts and surface, impermeable and resistant. With thermometer.	(4)Yes	(0)No	(4)NA
	2.4.2 Suitable equipment for controlling hot food and in good maintenance	(8)Yes	(0)No	(8)NA
	2.4.3 Perfect condition of cleanliness			
	2.5 Suitable cleanliness and disinfection	(8)Yes	(0)No	(8)NA
	2.5.1 Utilization of detergent and disinfectant products registered and approved?			
	2.6 Storage of utensils and equipment in safer and protected area against contamination	(8)Yes	(0)No	(8)NA
Part 3 Personal hygiene(employee hygiene practice	3.1 Suitable cloths			
	3.1.1 Use of proper apron or dungarees with light colour, proper shoes and cups that involve hair, in good maintenance	(2)Yes (8)Yes	(0)No (0)No	(2)NA (8)NA
	3.1.2 Strictly clean	(8)Yes	(0)No	(8)NA
	3.1.3 Suitable personal hygiene, body cleanliness, clean hands, short nail, without nail polish and adornment	(4)Yes	(0)No	(4)NA
	3.1.4 Suitable hygiene habits; hands washing before manipulation procedure and after the use of the toilet			
	3.2 Control of staff health			
	3.2.1 Absence of skin infection, sore and discharge, absence of respiratory infections, gastroenteritis (records to confirm)	(8)Yes (2)Yes	(0)No (0)No	(8)NA (2)NA
	3.2.2 Realisation of periodic health examination (proof)			
Part 4 Quality of raw and ready to eat food	4.1 Control of the origin; raw foods and other products for sale from authorised supplier, packaging and labeling	(4)Yes	(0)No	(4)NA

	4.2 Normal sensory characteristics of raw foods, colour, taste, flavor, consistency and appearance without adulteration checked at delivery	(8)Yes	(0)No	(8)NA
	4.3 Suitable conservation; time and temperature conditions of the raw foods conservation and or products with safety quality issues	(4)Yes	(0)No	(4)NA
	4.4. Suitable packaging and identification, integrity of packaging and visible identification, shelf life observed	(8)Yes	(0)No	(8)NA
Part 5 Flow of production/handlers/service/ and quality control	5.1 Suitable flow			
	5.1.1 Linear flow in one direction, avoiding cross contamination	(4)Yes	(0)No	(4)NA
	5.1.2. Minor handling and hygiene	(8)Yes	(0)No	(8)NA
	5.2 Protection against contamination			
	5.2.1 Foods protected against waste, spit, insects and rodents	(4)Yes	(0)No	(4)NA
	5.2.2 Hazardous substances such as insecticide, detergent and disinfectants in identified storage and used safely	(4)Yes	(0)No	(4)NA
	5.3 Suitable storage			
	5.3.1 Perishable foods storage in freezer ($\leq$-18.0 ^{O}C) Refrigeration ($\leq$ 8.0 ^{O}C) and hot holding at 63 ^{O}C	(8)Yes	(0)No	(8)NA
	5.3.2 Foods storage in separate by type or group. on proper pallet, absence of strange, ruined or toxic material	(8)Yes	(0)No	(8)NA
	5.4 Immediate elimination of the food scrap	(4)Yes	(0)No	(4)NA
	5.5 Foods ready to eat with normal sensory characteristics/product for sale, colour, flavor, consistency and appearance	(4)Yes	(0)No	(4)NA
	5.6 Foods ready to eat with suitable packing and identification			
	5.6.1 Integrity of packaging with visible identification (name, manufacturer, registration number, shelf life)	(2)Yes	(0)No	(2)NA
	5.6.2 Label in accordance with legislation	(1)Yes	(0)No	(1)NA

	5.7 Suitable quality control of the raw foods, finished products and products for sale	(4)Yes	(0)No	(4)Yes
	5.8 Person qualified: worker with proper training for activity	(2)Yes	(0)No	(2)NA
	5.9 Laboratory analysis with proper frequency, all the batches produced in the establishment should be analysed	(2)Yes	(0)No	(2)NA
	5.10 Suitable transport protected and clean	(2)Yes	(0)No	(2)NA
Score	$P = (TS/\sum_1 - \sum_2) \times K$			
Average Score	(P1+P2+P3+P4+P5)/10			

2. **Student questionnaire**

Students

Please you are entreated to help the researcher by furnishing her with the necessary information on your food safety awareness and how it is working to your benefit. You are assured that this is strictly for academic purpose and your identity will not be disclosed.

A. Demographics students

1. Your gender please 1 [ ] Male 2 [ ] Female 2 [ ] Prefer not to say
2. Your level in school 1 [ ] first year 2 [ ] Second year 3 [ ] Third year 4 [ ] Fourth year
3. Please indicate your level of attendance to the school's dining hall for meals
   1[ ] All the time 2. [ ] Most of the time 3. [ ] Sometimes 4. [ ] Never
4. Please indicate the 3 (three) most frequently prepared meals for breakfast, lunch and supper

Breakfast	Lunch	Super	Most popular meal across board

5. What kind of meals are served in your kitchens
   1[ ] Hot 2[ ] Cold/Chilled 3 [ ] Warm 4 [ ] Both Hot and Cold
6. Please indicate your other forms of meal choices when in school

1[ ] My own stored food 2. [ ] From shops 3. [ ] Other food vendors in school

4. [ ] Home meals 5. [ ] None

B. Food borne diseases awareness

7. Have you heard about food poisoning before1 [ ] Yes 2 [ ] No 2 [ ] Not sure
8. If yes where did you hear it from, please tick as many as possible.

1[ ] On the news

2 [ ] TV

3 [ ] Awareness seminar

4 [ ] Parents information

5 [ ] Reading from books

6 [ ] Family member experience

7 [ ] From a friends experience in school

8 [ ] Personal experience

9. What are some of the symptoms that are associated with foodborne diseases
   1. [ ] Vomiting
   2. [ ] Diarrhoea
   3. [ ] Fever
   4. [ ] Stomach cramps
   5. [ ] Others please specify……………………………………..

10. Have you ever experienced this in school after eating some food?

    1. [ ] Yes 2. [ ] No 3. [ ] Can't remember

11. How did you confirm this was food poisoning/food borne disease

    1 [ ] School nurse 2 [ ] Doctors response 3 [ ] My own decision 4 [ ] N/A

12. Did you stay off school for some time? 1 [ ] Yes 2 [ ] No 3 [ ] N/A

13. If yes for how long

    1 [ ] 1 day

    2 [ ] 2 days

    3 [ ] 3 days

    4 [ ] 4 days

    5 [ ] 5 day

    6 [ ] More than 5 days

    7 [ ] N/A

14. Did you take medication? 1 [ ] Yes 2 [ ] No 3 [ ] N/A

15. Who paid the bill

    1 [ ] National Health Insurance

    2 [ ] My parents

    3 [ ] Myself

    4 [ ] My school

    5 [ ] N/A

16. How much was spent on the foodborne illness

    1[ ] 1-10 GHC 2 [ ] 11-20 GHC 3. [ ] 21-30 GHC 4. [ ] 31-40 GHC

    5[ ] Above 50 GHC

17. How often do you have this problem in a term

    1[ ] Once 2. [ ] Twice 3. [ ] Three times 4. [ ] more than 4 5. [ ] Can't remember

    6. [ ] N/A

18. Do you have any food allergy? [ ] Yes [ ] No [ ] Don't know

19. Can you give the specific product you are allergic to?

    1 [ ] Nuts 2 [ ] Sea food 3 [ ] Gluten 4 [ ] Eggs 5 [ ] Monosodium glutamate

    6 [ ] Milk 7 [ ] Other, please specify…………………………..

20. If yes how does the kitchen help you in providing meals

    1[ ] I have not reported but avoid those meals

    2[ ] I have reported and I am given special diet

    3[ ] I have reported but I am not given any special diet

21. What changes do you think can be done to improve hygiene in the school kitchen

    1[ ] More potable water

    2 [ ] Hot food

    3 [ ] Clean utensils

    4 [ ] Protective uniforms

    5 [ ] Hand washing facilities at the dining area

    6 [ ] Enclosed kitchen area

    7 [ ] Pest control

    8 [ ] Others? Please specify………………………………………………………….

22. Among the listed items/experience please tick any of them you have ever seen or experienced during school meals

    1[ ] Chemical in food 2 [ ] Funny Smell 3. [ ] Stones 4 [ ] metallic substance

    5[ ] Wood 6 [ ] Mould 7[ ] Human hair 8 [ ] Insect 9 [ ] other………………

C. Student hygiene practice

23. Do you wash your hands and or cutlery and plates before eating?

    1[ ] Yes 2[ ] No 3[ ] Sometimes

24. Do you wash your hands after visiting the toilet with soap and clean water?

    1[ ] Yes 2[ ] No 3[ ] Sometimes

25. Where do you get your drinking water from?

1[ ] Pipe borne water

2[ ] Tankers supplied externally

3[ ] School reservoir

4[ ] Borehole

5[ ] Rivers/stream

26. The water I drink is stored in

1. [ ] My water bottle 2. [ ] Bathing buckets   3. [ ] School provided storage containers 4. [ ] School water fountain   5. [ ] Other………

Thanks for your input

3. **Staff questionnaire**

Questionnaire to investigate availability of food safety management systems in school kitchens in UK as a comparative study to Ghanaian school kitchens

Kitchen staff

Please you are entreated to help the researcher by furnishing her with the necessary information on availability of FSMS and how it is working to your benefit in your set up. You are assured that this is strictly for academic purpose and your identity will not be disclosed.

D. Demographics kitchen staff (cooking)

27. Please indicate with the tick your position in this kitchen
    1 [ ] Team leader 2 [ ] Chef 3 [ ] Cook 4 [ ] Trainee 5 [ ] Other, please specify
    …………………………………
28. Your gender please 1 [ ] Male 2 [ ] Female 3 [ ] Prefer not to say
29. Number of years of working in school kitchens
    1 [ ] 1-5 2 [ ] 6-10 3[ ] 11-15 4 [ ] 16-20 5 [ ] >20
30. Number of years of working as a leader/Chef
    1 [ ] 1-5 2 [ ] 6-10 3[ ] 11-15 4 [ ] 16-20 5 [ ] >20 6 [ ] Never
31. Present Age range 1[ ] 19-29 2 [ ]30 -39 3[ ] 40- 49 4[ ] 50-59 5 [ ] > 60
32. Please tick your relevant academic qualification
    1[ ] Basic/primary education 2 [ ] Secondary 3[ ] HND 4[ ] First degree 5[ ] Second degree 6 [ ] none
33. Have you got hygiene certificate 1[ ] Yes 2[ ] No
34. Will you be happy to have training on Good Hygiene Practices? [ ] Yes [ ] No
    Please give reasons for your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
    ……………………………………………………………………………………
    …………………………………………………………………………………

E. CAC Section VI. Personal Hygiene requirements

35. Hygiene training providers 1 [ ] Formal education 2[ ] Government Agency 3[ ] Private group4 [ ] Work Place/Other please specify………….. 5 [ ] None

36. When did you receive the training 1[ ] 1 year ago 2 [ ] 2 years ago 3 [ ] 3 years ago 4[ ] 4 years ago 5[ ] more than 5 years 6[ ] Can't remember
37. When did you last receive training on the work related task? 1 [ ] during induction 2 [ ] every year 3 [ ] More than once a year 4 [ ] Never 5 [ ] other please specify……………
38. Were you asked to submit medical report from certified medical doctor before beginning this work? 1 [ ] Yes 2 [ ] No

You are given a table with 5 possible answers to choose from. Please answer the questions 12 to 24 below.

Serial No.	Variable	Most likely	Likely	Don't know	Unlikely	Most unlikely
13	I report to my manager when I have diarrhoea or other infectious disease					
14	My manager/matron gives me time off until 48 hours after diarrhoea is cleared					
15	I receive first aid when I am injured at work before continuing my job					
16	The kitchen has waterproof dressing and other items in store for wound dressing					
17	I always wash my hands before starting work					
18	I always wash my hands after using the toilet					
19	I use protective clothing during work					

20	These clothing are cleaned on daily basis					
21	I remove all my unapproved jewellery before work					
22	I do eat whiles working					
23	I frequently change my gloves at work					
24	All visitors who visit our kitchen are given protective clothing					
25	My supervisor checks on our activities all the time					

F. Section VII-Establishment: Hygienic processing requirements

Please choose the appropriate answer to the following questions

26. Raw materials or ingredient that are not of acceptable quality are
    1. [ ] Returned to supplier
    2. [ ] Accepted and worked on to improve quality
    3. [ ] I don't know since I am not asked to check
    4. [ ] Reported to matron and put aside
    5. [ ] Used any way
27. Where do you store your raw protein like fish, chicken and beef?
    1. [ ] kitchen
    2. [ ] Store room
    3. [ ] Chiller
    4. [ ] Freezer
28. Where are your grains and cereals stored?
    1. [ ] Kitchen
    2. [ ] Matrons office

3. [ ] Dry store room
4. [ ] School storage

29. The refrigerator for fresh produce is always at $\leq 4.0\ ^{O}C$

1[ ] Yes
2[ ] Don't know
3[ ] I have never checked
4 [ ] It is not my job

30. Freezers for our long term storage is kept at -18.0 ^{O}C

1. [ ] Yes
2. [ ] Don't know
3. [ ] I have never checked
4. [ ] It is not my job

31. I make sure our colour coded equipment are always used for the right jobs

1. [ ] Yes
2. [ ] Sometimes
3. [ ] Don't have colour coded items
4. [ ] Limited resources does not allow this

32. Defrosting/thawing is done in the

1. [ ] in the refrigerator
2. [ ] Under running water same day
3. [ ] Overnight in cold room
4. [ ] in microwave oven
5. [ ] Over night at room temperature

33. Fats and oil for frying are changed when? Please tick all that is relevant to you.

1. [ ] it changes colour
2. [ ] when it changes odour
3. [ ] when it has too much debris
4. [ ] Don't change just add extra new oil
5. [ ] Don't do frying

34. Cooked meat is said to be done by

1. [ ] Visual inspection
2. [ ] Tasting
3. [ ] Using food thermometers
4. [ ] When Matron approves

35. What happens to cooked food that is not used same day?

1. [ ] Chilled
2. [ ] Covered and stored in a cool room
3. [ ] Left in kitchen over night
4. [ ] Don't store cooked food overnight

36. On the average how long does it take after dishing food before students come to eat

1. [ ] 30 minutes
2. [ ] 1 hour
3. [ ] 2 hours
4. [ ] 3 hours
5. [ ] Not sure

37. How is food to be served hot kept after cooking

1. [ ] On fire at lowered temperature
2. [ ] In hot cupboards
3. [ ] Temperature is not monitored
4. [ ] We do not have temperature monitoring and control systems
5. [ ] We always try to complete cooking on decided safe time for dining time.

38. How else do you ensure food safety in your kitchen? Please tick as many as are applicable

1. [ ] Report to my superior when I see insects in the kitchen
2. [ ] I follow the clean as you go policy
3. [ ] Avoid using equipment used for raw food on cooked products
4. [ ] Report all unfamiliar issues to my superior
5. [ ] Do effective cleaning
6. [ ] Follow the standard sanitizing procedure
7. [ ] Make sure waste is properly disposed
8. [ ] Check food labels for use by/expiry dates before use

G. Food hygiene knowledge assessment. Please tick the appropriate answers.

39. Have you heard of or read about food poisoning before? [ ] Yes [ ] No
40. Does food poisoning exist? [ ] Yes [ ] No
41. What do you think causes food hazards? Choose as many answers as you can.

i. Pins ii. Ear rings iii. Insects iv. Broken plastics v. Witches vi. Cleaning agents vii. Bacteria viii. Fungi ix. Paint x. Viruses

42. Is the presence of Salmonella in food preventable? [ ] Yes [ ] No

43. How do you think we get bacteria in cooked food? Tick as many answers as you can.

i. By Cross contamination ii. By Under cooking food iii. Poor temperature control iv. From Customers v. By coughing on the food

44. Which of the following is caused by *Salmonella*

i. Malaria *ii*. HIV *i*ii. Typhoid *iv.* Measles *v.* Diabetes

45. How do you think we can prevent food poisoning? Choose as many as you can.

i. Avoid buying food ii. Good personal hygiene iii. Effective temperature control iv. Praying before you eat v. Good waste management

46. When is it appropriate to wash hands? Choose the right answers

i. After visiting the toilet
ii. Before starting work
iii. After touching raw fruits
iv. After lunch break
v. When the supervisor is in

47. Who is directly responsible for keeping food safe? Choose the right answer.

i. All food handlers ii. The Manager iii. The supervisor iv. Mothers v.The Government

48. Which of the organisms below causes only changes in sensory qualities of food

i. Spoilage microbes ii. Pathogenic microbes iii. Don’t know

49. At what temperature should chilled foods be kept?

i. 0 -----5
ii. 10-----15 ^{O}C
iii. -5--------0 ^{O}C
iv. > 10 OC

50. What is the ideal freezing temperature for shorter shelf life products

i. -15 ^{O}C ii. <-18 ^{O}C iii. 0---- -5 ^{O}C iv. -13 ^{O}C v. >0 ^{O}C

51. What is the hot holding temperature?

i. 50 ^{O}C ii. 60 ^{O}C iii. 63 ^{O}C iv. 10 ^{O}C v. 100 ^{O}C

52. Choose the correct procedures

i. Wash, rinse, sanitize, rinse

ii. Wash , sanitize, wash, rinse

iii. Rinse, wash, rinse, sanitize

iv. Sanitize, wash, sanitize, rinse

53. Do we have Food Laws in Ghana?

i. [ ] Yes ii. [ ] No iii. [ ] I am not sure iv. [ ] Don't Know v. [ ] We should have?

Thanks for your input

4. **Matrons questionnaire**

Questionnaire to investigate availability of food safety management systems in school kitchens in UK as a comparative study to Ghanaian school kitchens

Kitchen Managers

Please you are entreated to help the researcher by furnishing her with the necessary information on availability of FSMS and how it is working to your benefit in your set up. You are assured that this is strictly for academic purpose and your identity will not be disclosed.

A Type of food set up

8. Please indicate your type of industry with a tick
   1[ ] Government 2[ ] Private 3[ ] Government/Private partnership
9. Years of existence 1 [ ] 1-10 years2 [ ] 11-20 years 3 [ ] 21 – 30 years 4 [ ] >40 years
10. Number of kitchen staff 1[ ] 1-10 2 [ ] 11-20 3[ ] 21-30 4[ ] 31-40 5[ ] > 40
11. Type of kitchen 1 [ ] Centralised kitchens 2[ ] Onsite kitchens
12. Type of meals provided. Please tick as many as are applicable
   1[ ] Hot meals 2[ ] Cold meals 3[ ] Both
13. Please in the table below provide three (3) of the most frequently prepared meals for students during breakfast, lunch and supper if applicable

Breakfast	Lunch	Super	Most popular meal across board

14. Number of students that are fed by this kitchen1 [ ] 1-500 2 [ ] 501 -1000 3 [ ] 1001 – 2000 4 [ ] >2000

B. Demographics of Technical managers/Supervisors/Matrons

15. Please indicate with the tick your position in this kitchen 1 [ ] Technical manager 2 [ ] Supervisor 3[ ] Matron 4 [ ] Team leader
16. Your gender please 1 [ ] Male 2[ ] Female 3[ ] Prefer not to say

17. Number of years of working in school kitchens 1 [ ] 1-5 2 [ ]6-10 3 [ ] 11-15 4[ ] 16-20 5 [ ] >20
18. Number of years of working as a Technical person/Manager/Supervisor 1[ ] 1-5 2[ ]6-10 3 [ ] 11-15 4[ ] 16-20 5[ ] >20
19. Present Age range 1[ ] 19-29 2 [ ]30 -39 3[ ] 40- 49 4[ ] 50-59 5[ ] > 60
20. Qualification of Technical personnel/Manager/Supervisor 1[ ] Secondary education 2[ ] Higher National Diploma 3 [ ] Degree 4[ ] Second degree
21. Qualification in hygiene of technical personnel 1 [ ] Yes 2 [ ] No
22. Hygiene training providers 1 [ ] Formal education 2[ ] Government Agency 3 [ ] Private group 4 [ ] Other please specify ……………………………

C. Availability of food safety management system

23. Do you have a Food safety management system? [ ] Yes [ ] No
24. Please tick as many as are applicable [ ] CODEX [ ] SFBB [ ] GMP [ ] HACCP [ ] Industrial guidelines [ ] Safe Catering [ ] Assured Safe Catering [ ] Other please specify……………………………….
25. Do you have documented prerequisite programs 1 [ ] Yes 2 [ ] No
26. How often are they reviewed 1 [ ] annually 2 [ ] twice a year 3[ ] three times a year 4 [ ] other, please specify………………………………………………………..
27. Please tick the those in place
    1. Supplier control
    2. Raw material specification
    3. Cleaning
    4. Waste management
    5. Pest control
    6. Personal hygiene
    7. Staff Training
    8. Planned preventive maintenance
    9. Transport
    10. Stock control and rotation
    11. Others please specify………………………………………………..
28. Do you have a HACCP System in place 1[ ] Yes 2 [ ] No
29. If yes how long has it been implemented 1 [ ] under a year 2 [ ] 1-3 years 3 [ ] 4-5 years 4[ ] > 5 years 5 [ ] Not available

30. If no, would you be interested in implementing HACCP in your school

    1[ ] Yes 2 [ ] No 3 [ ] Already has

31. If you responded No to the previous question, please indicate why you are not interested

    1. [ ] It is not required by Law
    2. [ ] So far we have not got any problem with food poisoning
    3. [ ] I don't think it is relevant
    4. [ ] We don't have time for these things
    5. [ ] I don't know how to

32. What are some of the challenges you envisage in implementing HACCP in your school?

    1[ ] Lack of time on behalf of staff to maintain

    2[ ] Lack of infrastructure

    3[ ] Lack of finance

    4[ ] Unavailable technical persons to establish

    5[ ] Lack of interest as we do not currently have problems

    6[ ] Cost of training

    7[ ] Any other? Please specify…………………………………………………….

33. If training on Good Hygiene Practices was to be made available without cost to the set up will staff be available for it? 1. [ ] Yes 2. [ ] No. Please give reasons for your answer…………………………………………………………………………………

    …………………………………………………………………………………………

    ………..

34. Do you have an auditing schedule 1[ ] Yes 2 [ ] No

35. Who is responsible for auditing, please tick as many as possible

    1[ ] Technical manager/Team 2[ ] Food and Drugs Board 3 [ ] Supervisor 4 [ ] Environmental Health officers. 5[ ] Circuit supervisor 6 [ ] SHEP coordinator 7. [ ] Other. Please specify……………………………………………

36. How often is auditing done1 [ ] once a year 2 [ ] twice a year 3 [ ] three times a year 4[ ] other Please specify……………………………………………………………….

37. What happens to non-conforming products please tick any applicable 1[ ] quarantined and investigated 2 [ ] Destroyed 3 [ ] reworked 4[ ] used any way

38. Do you maintain the supplier lot number when you receive raw materials 1[ ] Yes 2 [ ] No

39. What happens to out of specification raw materials 1[ ] returned to supplier 2[ ] used any way 3 [ ] Never had any problem like that 4 [ ] Don't know because we don't check
40. Internally are you able to trace an ingredient from start to finish? 1 [ ] Yes 2[ ] No
41. Do you have a means of tracing your products from supplier to service? 1[ ]Yes 2[ ] No
42. How long does the traceability process take 1 [ ] 4 hours 2[ ] 4-6 hours 3 [ ] 6-10 hours 4[ ] > 10 hours 5 [ ] >24 hours

D. Available control measure/strategies in use for hazard/disease avoidance.

You are only to answer the questions below if you answered no to Questions 16, 18, 21

43. In very short statements indicate how you control food hazards in your kitchen.

Biological/Microbiological	Physical	Chemical
I	I	I
Ii	Ii	Ii

44. Are there some foods you will not serve for safety sake? 1. [ ] Yes 2. [ ] No. Please list………………………………………………………………………………………………

Thanks so much

5. GHP DOCUMENT

GOOD HYGIENE PRACTICES FOR SENIOR SECONDARY SCHOOL KITCHENS IN GHANA

(GHPFSHS)

A practical guide on GHP for school matrons, kitchen staff and other conventional kitchens

Author- Ababio Foriwaa Patricia

School:

……………………………………………………………………………………………

Head Master/Mistress

Name :

Signature :

Assistant Head Master/Mistress (Domestic)

Name :

Signature :

Matron :

Signature :

Content:

Introduction

Scope

Objective

Definitions

Acknowledgment

Good Hygiene Practices:

Management commitment

Facility design

Raw material handling and Supplier control

Cleaning

Waste control

Pest control

Equipment maintenance

Personal hygiene and Staff training

Process control

Consumer information and protection

Non-conformance and corrective action table

Good Hygiene Practices for School matrons and staff in Ghana

Introduction

Good food hygiene practice is the holistic approach to producing safe food for consumers. Food that is safe brings no risk and is said to be not injurious to health. Food comes in various forms from various sources. From farm gate that is the primary producer through the food chain (delivery vehicles, ware houses, retailers, processors and manufacturers) until it reaches the consumer. Along this farm to fork path food is subjected to different kinds of treatment, handling and control. These steps that are taken at each stage of the chain aiming at ensuring safety of the food when consumed at its final destination is what we call good food hygiene practices. They include conscious effort by the food handler to control hazards in the raw material and its environment in order to prevent, reduce or eliminate hazards associated with the food.

Food may become contaminated by many agents including bacteria, viruses, parasites, chemicals and physical hazards. Transmission could occur by non-food mechanisms examples are contact with animals, poorly cleaned food contact surfaces and consumption of contaminated water. The level of effect of food hazard to the consumer also differs. With microbiological hazard the factors include the level of pathogens present in food, the kind of pathogen in question and host characteristics including age and immunity of the consumer. Vulnerability has been identified for a group of people in our society who may suffer severely from poor hygiene practices by food handlers and these include pregnant women, babies, lactating mothers, the aged and the immuneocompromised individuals in the society.

Safe food production is a legal requirement worldwide and in Ghana our Food Laws demand certain level of awareness and effort on the part of the food handler to ensure safety. The PNDCL 305B has several sections that puts a legal demand on all processors and manufactures on ensuring safe food for the consumer. It is imperative that all food handlers are given training that commensurate with their duties.

This book seeks to assist matrons and staff in school kitchens and other small scale industries with the systematic way of developing and implementing good hygiene practices in their kitchens.

Scope

This book covers the prerequisite measures (Good Hygiene Practices) necessary for the establishment of Food Safety Management Systems for schools in Ghana.

It covers the major and applicable steps in a basic food service environment with limited resources. Steps towards the development of standard operating procedures, with examples of records and work instructions also added.

Objective

This book is to support our hard working matrons in providing safe food for our school going age populace and also to be able to work within the minimum hygiene requirement set by the WHO/FAO's Codex Alimentarius and the 1992 Food and Drugs Law, PNDCL 305B of Ghana.

Acknowledgment

Special thanks goes to the Most High God who has been my counsellor, leader, protector and support all these years and the years to come.

The Regional Education Director, Heads of SHS's in Ashanti Region of Ghana, their matrons and kitchen staff have been of tremendous help in providing the necessary information and cooperating with me from the beginning of this programme to the end. I am forever grateful and pray that the Lord I serve will continue to make all of you successful in all your endeavours.

My family and friends who supported and encouraged me financially and spiritually, your good works follow you and will be remembered by the Lord God Almighty**.**

Finally my sponsor (University of Education, Winneba), I am grateful for the exceptional support you have rendered. God bless UEW**.**

Dedication

This work is dedicated to Sammy, Koby and Junior.

Definitions

Food

Any substance which when eaten provides the body with the essential nutrients for growth, energy and vitality.

Hygiene

The various practices and procedures that ensure good health

Food Hygiene

The measures and conditions in food handling including preparation that ensure the control of hazards in food when eaten.

Food Law

Statutory good practices requirements for the food processing and manufacturing industry

Safe food

Food that is devoid of physical, chemical and microbiological hazards

Quality Food

Food that meets the agreed specification (nutritional, safety and aesthetic values) set by the consumer

High Risk Food

Food capable of supporting rapid and progressive growth of infectious and toxigenic micro organisms, under suitable conditions and will not receive subsequent heat treatment before consumption.

Prerequisite measures

These are the good hygiene practices that need to be in place before implementing HACCP in food preparation to help the HACCP Plan to concentrate on the most significant Hazards

Risk

It is the likelihood of a hazard occurring in food

Equipment

They are the kitchen tools, containments and machines used in production

Waste Control

The effective management of waste produced during production to prevent cross contamination of food

Pest

Insects, birds, rodents and other animals that can directly or indirectly contaminate food.

Insect and Pest control

The effective management of insects and pest in a food production environment that ensures safe food

Integrated Pest Management

The use of both internal and external resources and measures to control insect and pest ingress.

Staff training

The instructions and supervision given to food handlers to ensure food hygiene and their safety in their daily activities

Training matrix

The planned instructional objectives set within a stipulated period for staff

Personal hygiene

They are the measures a food handler takes on an individual level to ensure food safety and include effective hand washing regime, the use of protective uniforms, absence of jewellery, reporting and control of infectious diseases.

Food transmissible diseases

These are human disease that are contracted through the ingestion of food. eg salmonellosis and dysentery.

Cleaning

The use of physical, chemical, biological agents and/or a combination of two or more of these to remove soil, dirt, dust and any foreign matter.

Detergents

Chemical agents that are used in conjunction with water to loosen and remove dirt and hold it in suspension, avoiding re deposition.

Disinfection

It is the destruction of microorganisms but not usually bacterial spores. It may not kill all microorganisms but reduces them to a level which is neither harmful to health nor the quality of perishable foods. It can be achieved by using heat, chemicals, irradiation or UV radiations.

Sterilisation

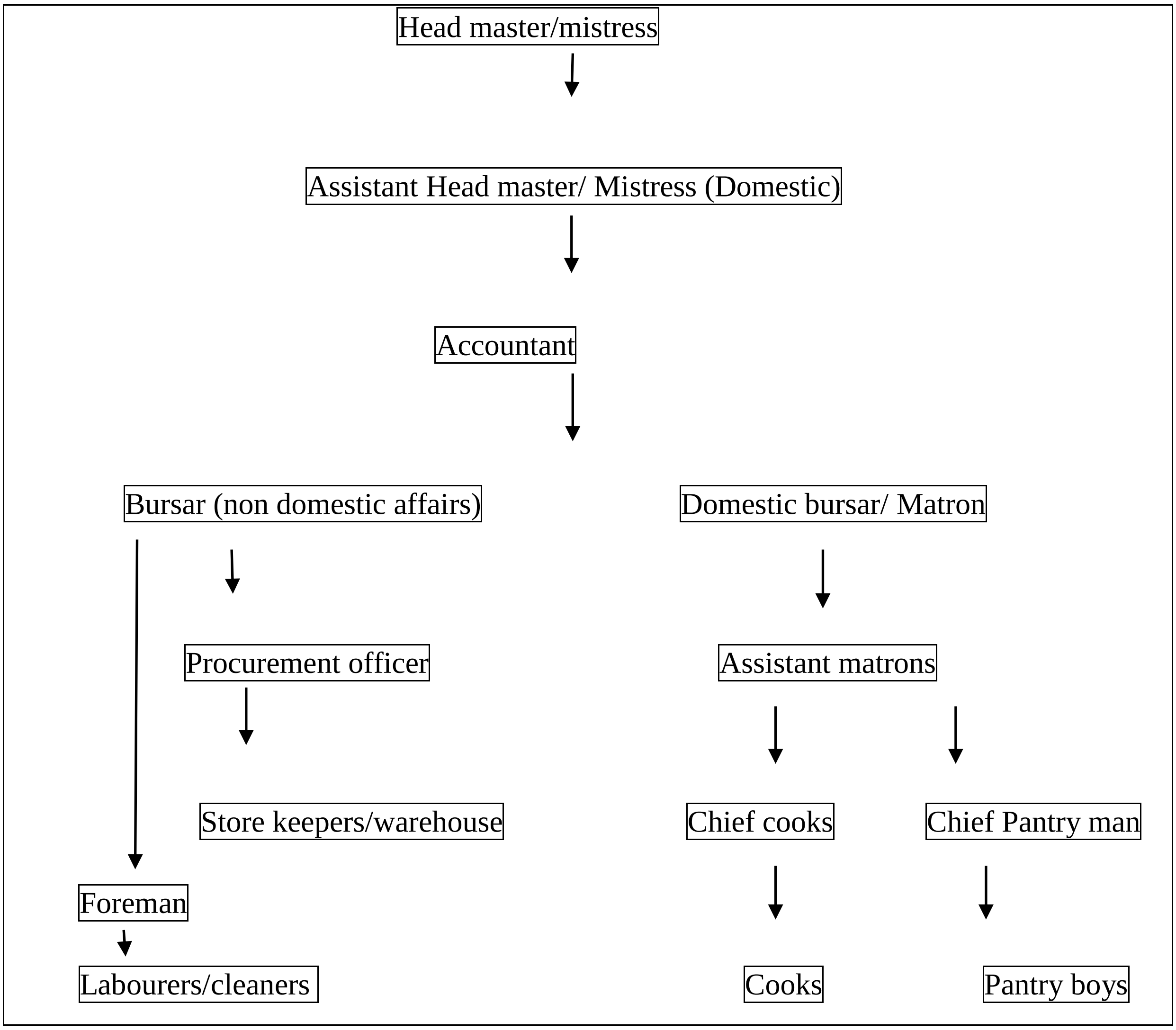
This relates to the destruction of all micro- organisms and spores and is normally unnecessary and impracticable to achieve within the food industry (Sprenger, 2009).

Management Commitment

Management Commitment

With every good system, the commitment of management is crucial in ensuring it's development and maintenance. The provision of the needed materials, time and human resource are paramount in the maintenance of every good system. After implementation, supervision and monitoring by trained staff is also essential.

Hierarchy of staff who directly and indirectly handle food and food issues



Roles and Responsibilities of Kitchen Staff

Roles of the matron/Kitchen manager:

Role of assistant matrons:

Role chief cook:

Role of cooks:

Role of Pantry leader:

Role of Pantry men:

Role of cleaners:

Facility Design/Process Design

Facility Design/Process Design

An enclosed kitchen with proper ventilation with washable walls, doors, ceiling and floors that are well maintained. This is paramount in ensuring food safety. The following have been outlined to ensure compliance.

U/L Kind of Kitchen

The kitchen has been designed with safety in mind to avoid cross contamination. Yes [ ] No [ ]

Our design ensure the flow of food from reception to service . Yes [ ] No [ ]

Physical segregation

Food processing, equipment and staff have been segregated to ensure food safety. Yes [ ] No [ ]

Water-

There is a source of clean potable water for drinking and food preparation. Yes [ ]No [ ]

Lighting

Sufficient source of light that aids food preparation and prevents the straining of eyes. Yes [ ] No[ ]

Lights are fitted with proper protection against food contamination. Yes[ ]No [ ]

Fitted doors and windows

There are fitted doors to control unauthorised access to the kitchen by both humans

and animals .
Yes [ ] No[ ]

There are fitted windows with screens that control pest and insect ingress Yes [ ] No [ ]

The doors and windows are washable Yes [ ] No [ ]

Floors/Walls/Ceiling

Floors are washable and are properly maintained Yes [ ] No[ ]

Walls are made of washable and non contaminable material Yes[ ] No[ ]

Ceilings are cleaned and well maintained and of non contaminable material Yes [ ] No[ ]

Drains

There are available drains to avoid the stagnation of waste water Yes [ ] No [ ]

Drains are maintained/cleaned on routine bases to ensure food safety Yes [ ] No[ ]

Drains are covered in the production area to avoid pest and insect ingress Yes[ ] No[ ]

Drains

Equipment locations

Equipment locations ensure;

smooth operation Yes [ ] No [ ]

easy access for cleaning and maintenance Yes [ ] No [ ]

safe food Yes [ ] No [ ]

safety of the operator Yes [ ] No [ ]

Raw material /Supplier handling

Raw material /Supplier handling

Food ingredients are required to be sourced from known sources with proper control over the safety and quality of the products. Food temperature, shelf life/expiry date, supplier hygiene practices and storage of produce after reception are measures which when controlled will ensure safe and quality food. No raw material or ingredient should be accepted in the establishment if known to contain parasites, micro organisms or toxic, decomposed or extraneous substances which will not be reduced to acceptable levels internally by normal kitchen procedures of sorting and/ or preparation or processing (Codex Alimentarius Commission, 1993)

There is a standard procedure for sourcing of raw materials. Yes [ ] No [ ]

Suppliers and products are well controlled. Yes [ ] No [ ]

There are specifications for raw materials received. Yes [ ] No [ ]

Suppliers deliver to our door step. Yes [ ] No [ ]

Vehicles for food transport are well maintained and do not present risk to food

Yes [ ] No [ ]

Food before receiving is inspected for expiry date and other useful labelling information

Yes [ ] No [ ]

The following materials are sourced from open market

Ingredient	Sourced from open market	Reason

Food Storage

There is available storage space for food ingredients Yes [ ] No [ ]

Freezers/fridges are available for cold storage Yes [ ] No [ ]

Freezer/fridge temperatures and are controlled Yes [ ] No [ ]

There is available space for dry ingredients Yes [ ] No [ ]

First in First out rule is followed in the kitchen. Yes [ ] No [ ]

Supplier Control Record

Food Ingredient/Non food items	Name of Supplier	Supplier's address	Phone Number	Email

Sample: Goods in and goods out records

Date received	Item/product	Supplier	Batch code	Use by date/BBD	Quantity received	Quantity Issued	Sign

Procedure for suppliers/ ingredients sourcing

Cleaning

Cleaning

Cleaning is essential in food preparation/processing environment. The daily activities of a caterer bring about dirt, soil, residue and other foreign matter into the kitchen environment that requires removal. Cleaning prevents the exposure of food to the risk of contamination. A cleaned surface will not have soiling or objectionable odour, is not greasy to touch and will not discolour a white paper tissue wiped over it (Sprenger, 2009). The PNDCL 305B section 7 requires a cleaned food preparation environment. Thus it is against the Law to produce food under unsanitary conditions. Cleaning should not however present any contamination risk to food, thus all foods need to be protected during cleaning. It is recommended that for food contact surfaces and areas where staff hands come into contact cleaning using detergents alone may not be enough to control microbiological build up and the use of other disinfectants (chemical, heat) may be useful.

Types of cleaning

Daily cleaning, this involves tools and equipment, tables, shelves, taps, fridges and door handles, light switches, kitchen floors, staff toilets etc that have direct contact with food and staff hands on daily basis.

Weekly cleaning, this involves surfaces that do not have direct contact with food and those that are practically unavailable for daily cleaning. eg Freezers, ceilings, light bulbs, fans, walls,

Periodic/deep cleaning involves other areas and equipment that do not come into direct contact with food and cleaning could be done for instance on monthly basis.

Kinds of cleaning equipment available and maintenance

Sponge , brooms /sweeping brush , scrubbers, mobs, squeegees , cloths, ceiling brushes, buckets and hose, vacuum cleaners , dishwashing machines etc

Maintenance of cleaning tools and equipment in the kitchen

A designated space or room (if available) should be made for cleaning tools and equipment. There should be laid down instructions on usage, proper cleaning of the tools after use and placement at designated area for proper storage as required.

Tools should be hanged preferable on hooks/hangers provided for effective drying if applicable.

Cleaning chemicals in use

Detergents (soaps) whether liquid or solid should be suitable for purpose, available, safe to use without damage to the surface or individual using it.

Disinfectants are required only for areas that have direct contact with food and has the characteristic microbial contamination or areas that can harbour micro organism including staff toilets.

Storage and usage of chemicals

There is a designated storage area for cleaning agents in the kitchen which is far from food storage area.

Yes [ ] No [ ]

Staff authorised to issue cleaning agents have been trained on right dosage. Yes [ ] No [ ]

Authorised staff have been trained on the risk associated with the chemical. Yes [ ] No [ ]

Safety data sheet on chemicals in use have been provided by the suppliers. Yes [ ] No [ ]

Chemical containers are properly labelled.

Yes [ ] No [ ]

Hand washing basin

There are available hand washing basins at designated areas (kitchen and toilets)

for staff hand hygiene.

Yes [ ] No [ ]

Cleaning agents including detergents, anti bacterial agent running water, wipes are provided Yes [ ] No [ ]

Staff have been trained on proper maintenance of hand washing basin. Yes [ ] No [ ]

Staff have been trained on replenishing the consumables at the hand washing area**.** Yes [ ] No [ ]

Sinks in food preparation area

These have been assigned for washing and cleaning of food and utensils Yes [ ] No [ ]

Cleaning Procedures for food contact surfaces

Whatever the location, industry, soiling type or circumstances, cleaning has six (6) main stages:

1. pre-clean: sweeping, wiping or scraping off loose debris, pre-rinsing and or pre soaking
2. main clean: use of detergent and loosening of the main body of dirt manually or mechanically
3. intermediate rinse: removal of loosened dirt and detergent residues
4. disinfection: destruction of remaining micro – organisms
5. final rinse: removal of disinfectant residue (if required) and
6. drying: removal of final rinse water and storing to prevent contamination.

Sponge and other cleaning agents control

Pantry and other staff in charge of washing have been trained on the appropriate area

to store sponge and soap in use. Yes [ ] No [ ]

Staff have been trained to clean the sponge and air dry it after use. Yes [ ] No [ ]

Staff have been trained not to leave sponge and soap on the floor Yes [ ] No [ ]

All chemical containers are appropriately labelled to avoid wrong use and food contamination.

Yes [ ] No [ ]

Sample : **Cleaning schedule**

Area/equipment	Frequency of cleaning	Cleaning material required	Cleaning chemical required and dosage	Contact time (if applicable	Cleaning method and time taken	Protective clothing required	Staff responsible	Supervisor

Related records

1. List of tools and equipment to be cleaned

2. List of areas in and around the kitchen that require cleaning

Waste control

Waste control:

Waste are the unwanted by products during food preparation. They arise from raw materials/ingredients, equipment in use and staff. These are required to be removed to ensure a safe environment during food preparation. Waste left in food production area over night brings foul odour, attracts pest and insects and serve as a contaminating bait as staff touch the receptacle and refuse. It is therefore essential that waste produced are removed from food preparation area to a designated waste storage area in the peripherals of the building where there is easy access for final disposal by persons in charge. The receptacles (bins, baskets, buckets, wheelie bins, skips) must be movable, easy to use, have suitable tight fitting lid, impervious and capable of being cleaned. After disposal, waste receptacles and floor should be kept cleaned after each emptying.

Kinds of waste produced in the kitchen;

Food waste Yes [ ] No [ ]

Cardboards Yes [ ] No [ ]

Glasses Yes [ ] No [ ]

Plastics Yes [ ] No [ ]

Stones Yes [ ] No [ ]

Insects Yes [ ] No [ ]

Broken ceramics Yes [ ] No [ ]

Control of waste produced in the kitchen

The kitchen practices waste segregation (recyclable and non recyclable) Yes [ ] No [ ]

Proper containment of waste are available (bins with lid) Yes [ ] No [ ]

Waste bins and floor are cleaned after food preparation Yes [ ] No [ ]

Sources of waste control services available

Waste is disposed of by external service providers Yes [ ] No [ ]

Waste is disposed of by internal arrangements Yes [ ] No [ ]

List of waste control service providers to the kitchen (if available)

Waste service provider	Type of waste taken	Frequency	Contact details	Phone numbers

Pest and insects control

Pest and insects control:

The presence of rodents (mice and rats) and insects (cockroaches, house flies, ants, wasps and stored product insects), birds and animals in food producing or preparation environment serves as a contamination risk. Their physical presence, droppings including faeces, urine, and broken parts could contaminate food bringing about possible food poisoning. Rodents, birds, flies and cockroaches are all capable of transmitting food poisoning organism and a range of additional viral, bacterial, protozoal and endoparasitic diseases, either directly by contact with food from their contaminated bodies or legs, by faecal deposits or in the case of rodents, by urine (Sprenger,2009).

Mode of control

External suppliers / control service in use. Yes [ ] No [ ]

Internal control system in use. Yes [ ] No [ ]

Integrated pest management (IPM) Yes [ ] No [ ]

Pest control strategy (in house control)

Effective cleaning and waste disposal Yes [ ] No [ ]

Check deliveries before reception Yes [ ] No [ ]

Staff trained to report on sighting pest or signs of their presence Yes [ ] No [ ]

Daily inspection to monitor that IPM is working Yes [ ] No [ ]

Cracks and holed in buildings are reported and repaired Yes [ ] No [ ]

Other access denied (broken nets, windows etc) Yes [ ] No [ ]

Baits and traps in use against straying rodents Yes [ ] No [ ]

List of pest control suppliers and contact details

Name of contractor	Kind of contract	Frequency of visits	Address	Phone number

Equipment maintenance

Equipment maintenance

Equipment bought into the kitchen are expected to be of quality material, parts available for repairs durable, useful for purpose, easy to use, easy to clean and versatile. Whilst quality equipment ensures efficient operation, routine cleaning and planned preventive maintenance is required to keep them in good condition. Maintenance services and training on new equipment are mostly rendered by suppliers of the product, and this can be arranged during purchasing.

List of electrical/non-electrical equipment

Electrical / Non Electrical equipment	Date purchased	Supplier/Model	Manual supplied Yes/No	Staff in charge of operating /cleaning	Training on usage given to staff Yes/No	Training given by/ (Sign)

List of equipment in use and maintenance plan

Equipment	Location	Contractor	Contract plan	Address of contractor	Phone number of contractor	Last service date	Next service due on

Equipment cleaning schedule is available and followed Yes [ ] No [ ]

Routine maintenance is available for listed equipment Yes [ ] No [ ]

Personal Hygiene and Staff training

Personal Hygiene and Staff training

It is unlawful to produce food under unsanitary conditions (PNDCL 305B Section 7). The food environment and personnel are major sources of food contamination aside the risk associated with the food ingredients. Personal hygiene of kitchen staff is therefore very important when it comes to Good Hygiene Practices in the food preparation environment. Health status of kitchen staff, illness and injuries, personal cleanliness and staff behaviour during food preparation require monitoring and supervision to towards ensuring safe food. Visitors to the kitchen equally require a level of control towards prevention of contamination.

Personal hygiene objective

This is to ensure that those who come directly or indirectly into contact with food are not likely to contaminate food by:

*maintaining an appropriate degree of personal cleanliness

*behaving and operating in appropriate manner. (FAO/WHO Codex Alimentarius, 2009).

Health status: Dealing with infectious diseases in the kitchen

All kitchen staff are trained to report ill health and infections that could cause disease transmission through contact with food.

Yes [ ] No [ ]

Personnel suffering from the following are to be exempted from food preparation areas;

Jaundice,

Diarrhoea,

Vomiting,

Fever

Sore throat with fever,

Visibly infected skin lesions (boils, cuts, whitlow etc)

Personal cleanliness

Staff are provided with uniforms, hair covers, shoes and aprons (where necessary) to protect food from contamination.

Yes [ ] No [ ]

Beard covers (where applicable) and gloves (optional) are used to protect food from contamination.

Yes [ ] No [ ]

Staff Hand washing culture

Staff are trained to wash their hands with clean potable water and soap and dry their hands with clean towels;

before starting work

after visiting the toilet

after disposing rubbish

after touching raw meat or other materials that can contaminate food.

Yes [ ] No [ ]

Staff behaviour Monitoring

Staff are trained not to wear jewellery, watches, make ups, strong perfumes in the kitchen.

Yes [ ] No [ ]

Staff are trained to avoid;

smoking, spitting , chewing (eating), sneezing and coughing over unprotected food in the kitchen.

Yes [ ] No [ ]

Staff changing rooms

Changing rooms are available for both genders in the kitchen

Yes [ ] No [ ]

Staff are provided with suitable storage facilities for their belonging

Yes [ ] No [ ]

Changing rooms are monitored for cleanliness by designated/trained staff daily.

Yes [ ] No [ ]

Staff toilets

Sufficient sanitary conveniences are provided for both genders at suitable and readily accessible places.

Yes [ ] No [ ]

Toilets are adequately ventilated

Yes [ ] No [ ]

Toilets do not open directly into food preparation or storage areas in the kitchen

Yes [ ] No [ ]

Walls and floors of toilet are made of cleanable material

Yes [ ] No [ ]

Toilets are cleaned on a daily basis

Yes [ ] No [ ]

Staff hand washing facilities

There are suitable and sufficient hand washing basins for both genders

Yes [ ] No [ ]

Suitable detergents, sanitizers and wipers/dryers are available

Yes [ ] No [ ]

Consumables are supervised and replenished regularly to avoid the escape of good hand hygiene practice

Yes [ ] No [ ]

Training

Training programmes for personnel should commensurate (be appropriate) with their roles or duties. Training could be handled by kitchen matrons/managers internally whilst there are available private individuals, organisations and government agencies who could equally give the requisite training to staff at the different levels of responsibilities.. It is the responsibility of management including the matron to plan training programmes for kitchen staff to create hygiene awareness, improve on existing knowledge towards the maintenance of acceptable standards

Induction

Staff are formally introduced to the facility and staff, and given the necessary health and safety information upon employment.

Yes [ ] No [ ]

On Job training

Training on individual roles/duties is given to staff before work commences.

Yes [ ] No [ ]

Top up/refresher courses

Planned training programmes based on new technologies, changes in legislature, equipment usage, corrective actions towards non conformances etc are given to staff.

Yes [ ] No [ ]

List of training providers (if available)

Trainers	Programme	Contact Address	Contact Phone No.

Sample of planned training programme for new staff

Date:

		1ST Week	2nd Week	1st Month	2nd month	8TH month	Second year
Serial No.	Name of Staff	Induction date	Job specific training	Personal Hygiene	GHP	Health and safety	HACCP

Process control

Process control

The control of food from reception until product reaches the final stage is essential in order to ensure food safety and quality. Perishable foods, already cooked meals and dry ingredients require certain monitoring and control measures to remain safe for usage. Spoilage brings about cost as food is wasted and microbiological and chemical contamination too render food unsuitable for consumption. It is therefore necessary that all RTE (Ready to Eat) foods are produced under absolute control**.** Physical contaminants in food render them unwholesome and equally require control during food preparation.

Temperature and time control

The control of food temperature and time is essential to ensure food is safe when eaten. Micro organisms in food are able to increase in numbers beyond unacceptable levels when food temperature and time are abused. The acceptable storage temperature for frozen and chilled products (eg meat, poultry, fish) are -18.0 and 5.0-8.0 ^{O}C respectively. Acceptable hot holding temperature for ready to eat food is 63.0 ^{O}C (FSA, 2006).

Temperature monitoring equipment used in kitchen

The kitchen has;

Refrigerator/refrigerators	Yes [ ] No [ ]
Freezers	Yes [ ] No [ ]
Bain Marie	Yes [ ] No [ ]
Hot cupboards	Yes [ ] No [ ]
Temperature probes	Yes [ ] No [ ]

Others please list ....

....

Chilled/ Frozen food

Temperature of frozen food bought/received is controlled/monitored. Yes [ ] No [ ]

Temperature of frozen food in the kitchen is monitored. Yes [ ] No [ ]

Temperature of chilled products received in the kitchen is monitored Yes [ ] No [ ]

Refrigeration temperature during storage is monitored. Yes [ ] No [ ]

There are temperature monitoring devices on freezer/fridge Yes [ ] No [ ]

Probes are calibrated routinely. Yes [ ] No [ ]

Items in storage are properly labelled with use by/best before date Yes [ ] No [ ]

Cooked food

Cooked food temperature is monitored on daily basis. Yes [ ] No [ ]

Temperature of food at service is ≥ 63.0 ^{O}C. Yes [ ] No [ ]

Physical and Chemical Hazards monitoring

Raw materials received are checked for insect infestation beyond. Yes [ ] No [ ]

Raw materials received are checked against chemical contamination. Yes [ ] No [ ]

Unacceptable/non conforming ingredients are returned to suppliers. Yes [ ] No [ ]

Suppliers are monitored to ensure safe food. Yes [ ] No [ ]

Detergents and other chemicals in use are stored properly to avoid chemical contamination.

Yes [ ] No [ ]

Control measures are in place for hazards related with ingredients/ products.

Yes [ ] No [ ]

Glass control

The usage of glass in the kitchen is under strict supervision to avoid contamination risk.

Yes [ ] No [ ]

Personnel in charge of glass control policy

Date	Name	Training received	Sign

Water

Clean potable water is in use.

Yes [ ] No [ ]

Dug well is in use.

Yes [ ] No [ ]

Water quality and safety is checked routinely by a state recognised laboratory.

Yes [ ] No [ ]

Consumer Information

Food allergy information

Selected food/ingredients cause allergenic reactions among some consumers (students) and should be declared during service to avoid risk to health and abstinence from meals.

Some of the common and local food items/ingredients that consumers are **allergic** to or have some level of **intolerance** with include, eggs, pea nuts, beans, soya bean, milk and Mono sodium glutamate (MSG). Matrons in collaboration with school management should find ways of identifying all students with food issues including allergenic and intolerance conditions towards consumer's health.

List of students with allergic/intolerance conditions to particular food/ingredients is available in the kitchen.

Yes [ ] No [ ]

Separate meals are prepared for these groups

Yes [ ] No [ ]

Food labelling

Food labelling information is checked during deliveries

Yes [ ] No [ ]

Records are kept on raw materials received

Yes [ ] No [ ]

Food allergy **alerts** are given to consumers to avoid risk to health

Yes [ ] No [ ]

Non conformances and Corrective Action Plan

Date	Non conformances identified	Reported by	Corrective actions issued	Date to be completed	Responsibility	Date completed	Sign

References

Food and Drugs Authoriy of Ghana (1992) Food and Drugs Law. PNDCL 305B . FDA.

Food Standards Agency of UK (2006) Good Hygiene Practices. FSA UK.

FAO/WHO (2009) Codex Alimentarius commission, basic hygiene texts. Second edition. FAO/WHO Rome.

Sprenger, R. A. (2009) Hygiene for Management. 15th Ed, Highfield.co.uk ltd, Doncaster, UK.

Records

Kitchen staff record **Date:**

Serial No.	Name	Male/Female	Position	Duties

Cleaning Schedule

Date :

Equipment	Frequency	PPE	Method Used	Mon	Tue	Wed	Thur	Fri	Sat	Sun	Sign

Cleaning Schedule

Date :

Area	Freque ncy	PPE	Method Used	Mo n	Tu e	Wed	Thu r	Fr i	Sa t	Su n	Sig n

School:	Weekly Audit Record (In House) Date Beginning ……….					
	Week 1	Week 2	Week 3	Week 4	Week 5	Sign
Personal Hygiene						
Staff hand washing culture						
Detergent/soap at hand washing points						
Jewellery rules in house followed						
Protective uniforms in use						
Illness/exclusion rules in use						
Staff changing room clean and well maintained						
Cleaning						
Has the cleaning schedule been followed?						
All specified areas						
All specified equipment						
Hot water and soap in use						
Pest control						
Pest control checks done						
Corrective actions taken if any spotted						
Stores and other areas checked for proofing						
Waste control						
All waste carried out of kitchen at end of day						
Waste bins covered and cleaned after collection						
Waste area cleaned/washed routinely						
Maintenance						
All equipment in good working condition						
Breakages reported and corrected						
Stock control						
Delivery checks done (physical/chemical/temperature)						
Storage area in good condition						
Stock rotation rule followed (FIFO)						
Labelling checks done						
Temperature control						
Equipment temperature rules?						
Food temperature rules						
Delivery temperature rules						

House Rules Non Conformance	Corrective Actions Taken	Sign

School: **Personnel Sick and Return to Work Form**

Part 1

To be completed by all Food Handlers when returning to work after an illness

Name: ---
Date of Return: -------------------------

Please answer the following questions

During your absence from work, did you suffer from any of the following:

Please tick and date when symptoms ceased	Yes	No	Date
a. Diarrhoea?			
b. Discharge from gums/mouth. Ears or eyes			
c. A sore throat with fever			
d. A recurring bowel disorder			
e. A recurring skin ailment/ Witlow			
d. Any other ailment that may present a risk to food safety			

Have you recently taken any medication to combat diarrhoea or vomiting? Please tick

Yes	
No	

Signature of Food Handler …………………………………………………………………………..
Date…………………………………

Part 2 To be completed by the Manager/Matron

If the answer to all the above questions was No, the person may be permitted to return to food handling duties.

However if the answer to any of the questions was Yes, the person should not be allowed to handle food until they have been free of symptoms for 48 hours, OR if formally excluded, medical advice states that the person can return to their duties.

Alternatively in the case of food handlers with lesions on exposed skin(hands, neck or scalp) that are acitvely weeping or discharging , they must be excluded from work until the lesions have healed.

I confirm that Mr/Mrs/Madam…………………………………………………………………………… may resume food handling duties.

Signature: Manager/Matron……………………………………………………………………………

Date ……………………………….

Part 3. To be completed by the Manager or Matron

What medical advice was received by the employee? Please tick

a. Exclusion from work until medical clearance is given						
b. Move to safe alternative work until clearance is given						
c. Return to full food handling duties						

If (a) or (b) is ticked, appropriate action must be taken, if (c) is ticked, the food handler may resume duties
immediately

School:…………………… Daily Temperature Checks Week beginning ……………

Freezers/Fridges	Mon	Tue	Wed	Thur	Fri	Sat	Sun
1							
2							
3							
4							

Fridge temperature 0 - 8 ^{O}C/ Freezer Below - 18 ^{O}C

Food Temperature	Mon	Tue	Wed	Thur	Fri	Sat	Sun
Hot meals							
Breakfast							
Lunch							
Supper							
Cold/Chilled meals							
Breakfast							
Lunch							
Supper							

Hot holding temperature must be 63 ^{O}C and above, Cold meals 8 ^{O}C at service and Core of meat must be 80 ^{O}C for at least 6 seconds or 75 ^{O}C for 30 seconds

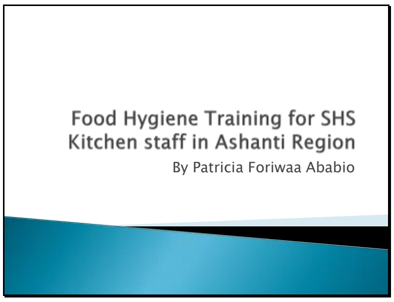
Fresh/Frozen Deliveries	Mon	Tue	Wed	Thur	Fri	Sat	Sun	Supplier	Use by date
Meat									
Chicken									
Yoghurt/Ice cream									
Other cold meals									

Chilled food delivery temperature between 0-8^{O}C, Frozen food at 18^{O}C

	Problems/Challenges and corrective actions taken to rectify them	**Matron Sign**
Mon		
Tue		
Wed		
Thur		
Fri		
Sat		
Sun		

6. POWER POINT PRESENTATION ON TRAINING INFORMATION

Slide 1



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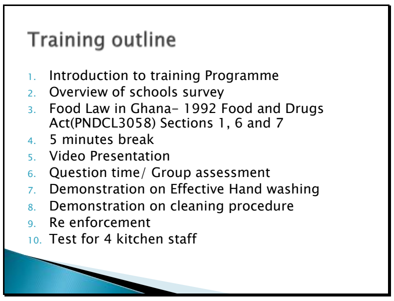


Slide 3

Food Hygiene

- It is the science of preserving health and involves cleanliness and all other measures necessary to ensure safe and wholesome food along the food chain.

Slide 4

Why bother?

- To help prevent, eliminate and or control possible hazards
- that could be a risk to the consumer
- Avoid bad publicity
- Avoid Law suits
- Maintain Consumer /student s trust

Slide 5

Parents and their wards (average of 2000 in a school) depend on us.

Slide 6

Statistics on food borne illness and poisoning cases in Ghana and schools (2007-2013)

Source/ Year	Home/Private	Schools	Commercial
GNA 2014 June		About 20 students hospitalised in Ho from Awudome SHS	
Myjoyonline May 2014	Kofi Ansah dies of suspected food poisoning		
Graphic June 2013 GNA July 2013	14 Medical students from UDS hospitalised from home food poisoning	40 SHS students rushed to hospital over suspected food poisoning at Twifo Praso SHS after evening meal	

Slide 7

Statistics on food borne illness and poisoning cases in Ghana and schools

Source/ Year	Home/Private	Schools	Commercial
Citi fm Online 2013		Over 40 students hospitalised in Adonten Sec. in E/R over Food Poisoning. Case under investigation	
Daily Guide 2011 Food Safety news	17 out of 28 farmers die of chemical food poisoning in Northern Region A whole family dies of food poisoning		Dozens (53) suffer food poising in Obuasi on Nov 13th after eating fried rice from a fast food joint and hospitalised (a mother and 2 kids involved)

Slide 8

Food borne illness and poisoning in Ghana continues

Source/Year	Home/Private	Institutional	Commercial
Joy News/ 2010 - 2009	Outbreak of food poisoning at a Child Naming Ceremony-Anyaa Ghana- locally made drink	Over 100 girls in Archbishop Porter Girls Hospitalised from food poisoning after eating in dinning hall Pupils reject insect infested meals supplied in school feeding programme	
2007-2008 Ministry of Health 2007		1, 348 children suffer food poisoning among school food served by contracted caterers Dozens of students from two public schools	40 persons suffer food poisoning at a salad joint at Koforidua Der *et al* (2009.) Causative agent *Clostridium*

Slide 9

Some report from survey– students

91% of SHS boarding students from Ashanti Region visit the dining hall all the time

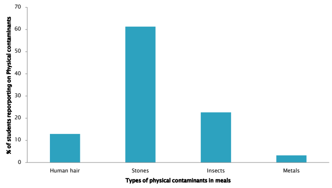
Existence of both reported and unreported cases of food borne illness in schools (51.7% of students sampled)

Food allergy and intolerance could be a factor in students not frequenting the dining hall

High level of physical contaminants in food

Slide 10

Level of physical contaminants reported by students



Slide 11

Kitchen staff– survey

- Jewelry and protective uniforms still not standardised.
- Hand washing before work not a culture
- Wiping hands in apron and other dresses
- Lack of soap, dryers and antiseptics for cleaning
- Lack of changing rooms or poorly managed rooms
- Cleaning of utensils not standardised (sponge kept on floor by cleaners)
- Poorly maintained storage area for utensils
- Reporting and exclusion from work of staff with infectious diseases and 48 hours rule not in practice

Slide 12

Temperature, time of service and micro information on Jollof

Hygiene category	School code	Food temp. ^{O}C	Service to dinner time(Min)	ACC log cfu g^{-1}	Coliforms log cfu g^{-1}	Fungi log cfu g^{-1}	Staph. spp log cfu g^{-1}	Bacillus cereus cfu g^{-1}
	026	68.50	30.00	3.91	3.29	3.46	2.00	2.78
	019	61.50	60.00	3.00	2.58	4.10	2.77	2.85
	010	59.50	57.50	2.98	2.99	2.27	2.15	2.27
	007	69.50	36.50	5.23	5.15	2.64	3.93	2.30
Mean		64.70	46.00	3.78	3.51	3.12	2.71	2.55
S.D		±4.99	±14.99	±1.06	±1.13	±0.80	±0.87	±0.31
	012	57.50	47.50	5.29	4.52	2.15	3.82	4.15
	005	54.50	35.00	3.69	2.52	2.91	2.53	2.96
	003	65.00	75.00	5.80	3.07	2.65	4.12	3.47
	002	49.50	35.00	4.19	3.35	3.83	3.80	3.15

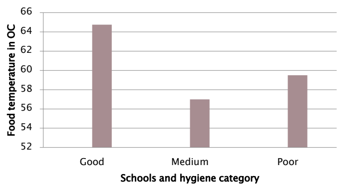
Slide 13

Food temp., service to meal time and micro. Report on Jollof and cooked rice

Hygiene	N	Food Temp ºC	Time (Min)	APC Log cfu/g	Coliforms Log cfu/g	Fungi Log cfu/g	Staph spp Log cfu/g	Bacillus cereus Log cfu/g
Good	4	64.75	46.00	3.78	3.51	3.12	2.71	2.55
Medium	4	57.00	48.12	4.75	3.49	2.88	3.57	3.44
Poor	3	59.50	57.50	5.04	3.77	2.92	4.25	4.08

Slide 14

Average temperature of Jollof/cooked rice from sampled schools



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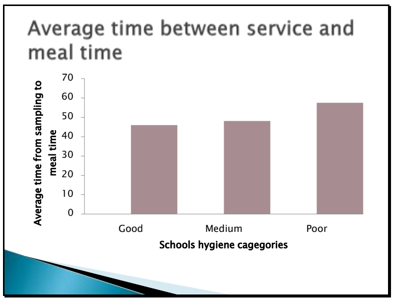

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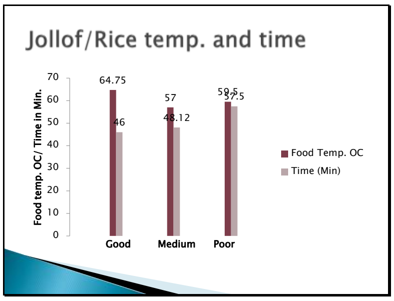

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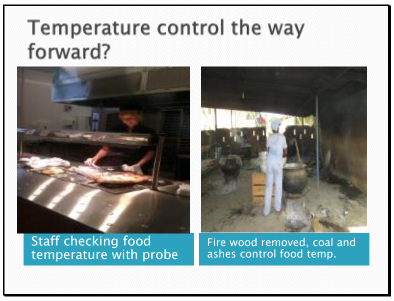

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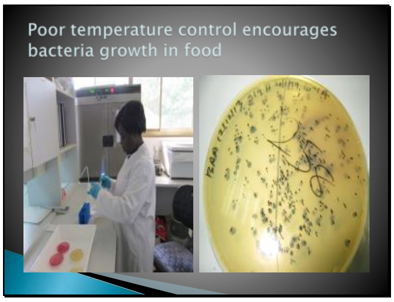


Slide 19

Food and Drugs Law of 1992, PNDCL 3058

- **1.Prohibition against sale of unwholesome food.**
- *2.* Food offered as a prize.
- 3. Deception of consumers.
- 4. Standards of foods.
- 5. Prohibition against sale of poor quality food.
- 6. **Manufacture of food under supervision.**
- 6A. Mandatory fortification of salt.
- 7. **Sale of food under unsanitary conditions.**
- 8. Food unfit for human consumption.
- 9. Penalty and defence.
- 10. Closure of premises

Slide 20

Slide 21

Slide 22

Slide 23

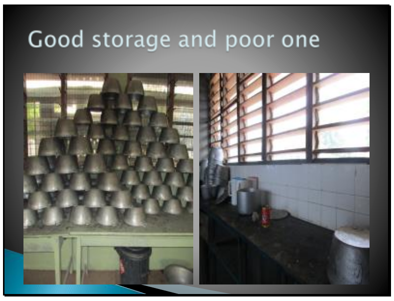
Slide 24

Slide 25

Slide 26

Slide 27

Slide 28



Slide 29

Slide 30

Good hygiene practices training and implementation

- 1. Good cleaning procedure*
- 2. Waste management
- 3. Pest control
- 4. Staff training*
- 5. Raw material storage*
- 6. Supplier control
- 7. Temperature control*
- 8. Personal hygiene*
- 9.Transport
- 10. Facility design
- 11. Maintenance

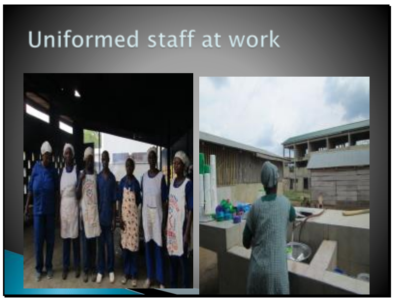
Slide 31

Staff training and supervision is the key

Slide 32

Same arrangement different environment

Slide 33



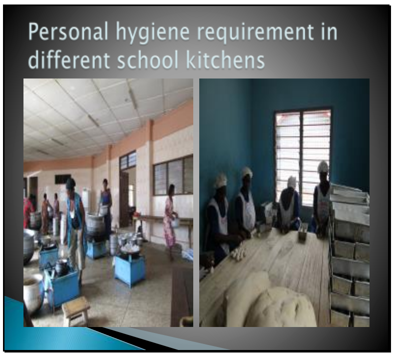
Slide 34

Slide 35

Slide 36

Slide 37

Slide 38



7. HACCP DOCUMENT (MICROBIOLOGICAL)

Hazard Analysis and Critical Control Point Document for cooked RTE meal (Jollof Rice) in SHSs in

Ashanti Region of Ghana

Senior Secondary Schools kitchens in Ashanti are cook serve caterings that serve an average of 2000 students three meals a day thus an approximately 6000 plates for students only. Kitchen staff and academic staff also partake of these meals as desired. Kitchen is run by a principal or domestic bursar, her assistant matrons ranging from two to five (2-5) and a group of cooks and pantry men. The school procurement officer does purchasing of most food ingredients but some perishables are left for the matrons to purchase on the open market on daily as and when required. Jollof rice is a favourite meal for most students.

HACCP Team

1. Technical expertise
2. Assistant Head Master (Domestic)
3. Domestic Bursar
4. Kitchen supervisors
5. Team leaders
5. Procurement staff

Available Prerequisites

Facility design	Supplier control- school procurement team
Cleaning	Waste management
Pest control	Personal hygiene

Staff training In process control (temperature and time)

*Water treatment

* not in schools but water treated from mains by Ghana Water and Sewage/ not available if bore holes are in use in schools

Scope

The HACCP Plan covers intake, storage, preparation and service

Product description

Product: (Jollof rice)

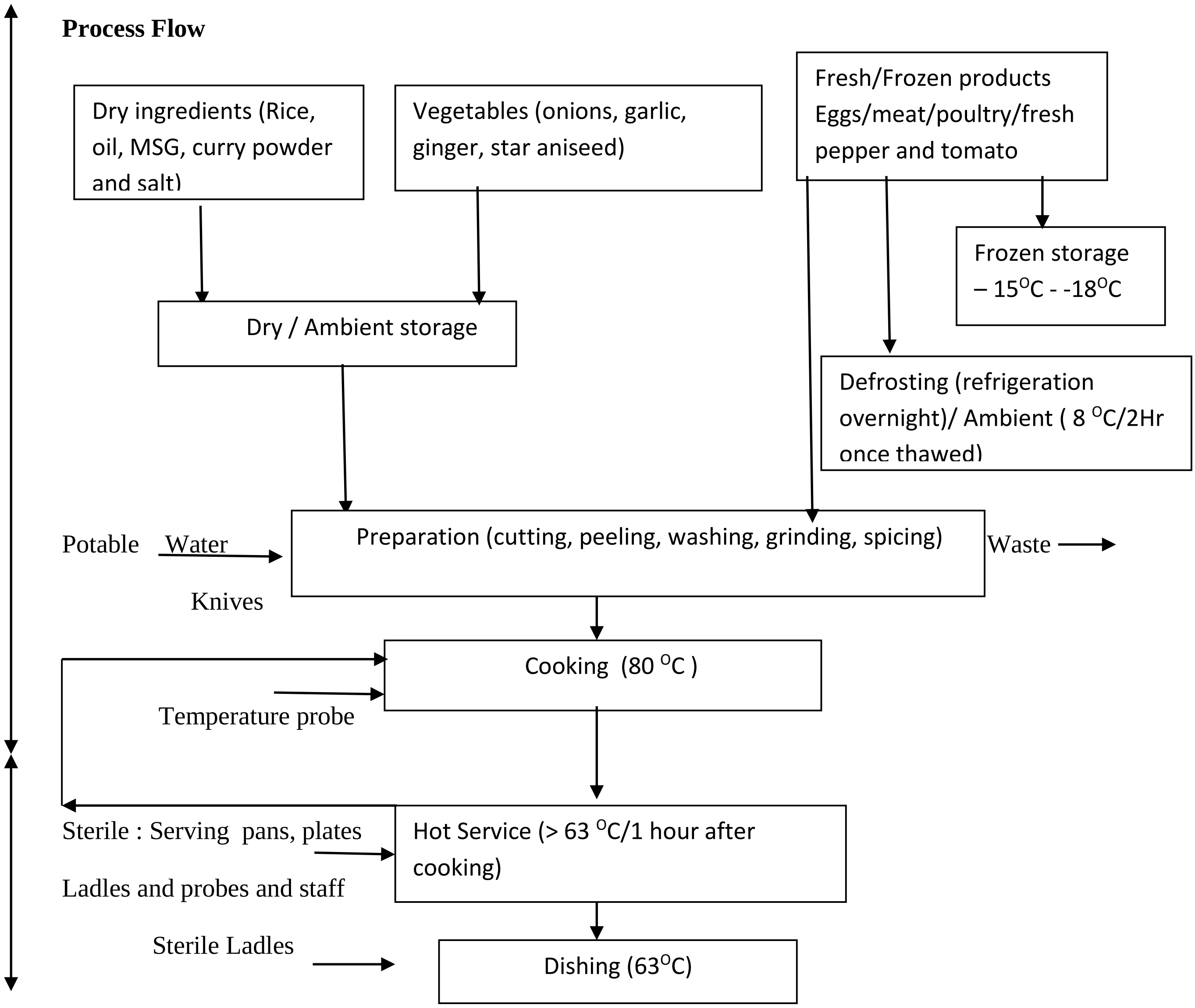
Target group : SHS students and staff

Intended use: Cooked and Served hot (RTE meal)

Ingredient List

Ingredients	Characteristics	Storage condition	Supplier
Rice	Dry	Ambient	Procurement approved supplier
Oil	Dry	Ambient	Procurement approved supplier
Canned tomato	Dry	Ambient	Procurement approved supplier
Raw vegetables (onion, garlic, ginger)	Semi dry	Ambient	Open market/Procurement approved supplier
Raw pepper and tomato	Fresh	Refrigeration/Freezer	Open market/ Procurement approved supplier
Dry spices (eg aniseed, cloves)	Dry	Ambient	Procurement approved supplier
MSG	Dry	Ambient	Procurement approved supplier
Curry	Dry	Ambient	Procurement approved supplier
Salt	Dry	Ambient	Procurement approved supplier
Egg/meat/fish/poultry	Fresh/Frozen	Refrigeration/Freezing	Procurement approved supplier
Water			

Process Flow



Hazard Analysis (microbiological)

Raw material microbiological Risk Analysis

Ingredient	Microbiological Hazards?	Are you going to process this hazard out of the product	Is there a cross contamination risk to the facility or to other products which will not be controlled?	Critical Control Point	Hazards
Rice	Yes	Yes	No	Not CCP	*Bacillus cereus*, *Clostridium perfringens*, mould
Oil	Yes	Yes	No		Mould
Salt	No				-
MSG	No				-
Fresh Vegetables	Yes	Yes	No	Not CCP	*Clostridium perfringes*, *Bacillus cereus*, *E. coli*, *Salmonella*, moulds , . Protozoans
Dry Vegetable	Yes	Yes	No		Mould
Meat/poultry/Fish	Yes	Yes	No	Not CCP	*Salmonella*, *Campylobacter*, *S. aureus*, *E. coli*, *Listeria monocytogenes* *Cytptosporidium parvum*, Enteric virus, Norfolk Virus and Hepatitis-A
Eggs	Yes	Yes	No		*Salmonella*

Notes

Avoiding cross contamination: Avoid the cross contamination of cooked rice, poultry, meat or egg, processing procedures and equipment, employees, and the environment by following appropriate sanitation procedures, good hygiene practices, and procedures for employee hygiene. It is particularly important to ensure complete segregation of raw meat from ready-to-eat products.

Controlling growth of microorganisms: keep the overall number of bacteria very low by controlling temperature, to restrict growth of pathogens.

Storage temperature -- The growth of most bacteria can be slowed (controlled) by maintaining the product at refrigeration temperatures (1-8°C), or by freezing (-15°C). Holding cooked products at higher temperatures (greater than 65°C) also restricts the growth of bacteria.

Destruction of Bacteria: Most pathogenic bacteria, including Salmonella, Escherichia coli O157:H7, *Listeria monocytogenes*, and Campylobacter, can be fairly easily destroyed by cooking -maintaining a minimum temperature within the range of 72°C for two minutes. However, this will not destroy the heat resistant forms (spores) of certain bacteria, nor will some types of toxins be destroyed if they have already been formed in the product.

Hygiene and sanitation: Some pathogens, such as *Listeria monocytogenes*, can be found in the processing environment. This emphasizes the need for adequate sanitation, not only of the equipments, but also the floors. Employee hygiene, air flow, and traffic flow of people and equipment between areas used for not-ready-to-eat processing and ready-to-eat processing is very important and should be strictly controlled.

Cooking up to 80 ^{0}C helps reduce microbiological load making the food safer for longer duration.

So, Food illnesses can be controlled by:

*Approved suppliers

*Controlled storage conditions- accurate temperature control (0 -8°C for chilled products, -15°c for frozen products), FiFo in use

*Segregation of raw and cooked meat

*GHP

*Maintenance of Temperature/time records for, freezers; calibration of probes

*Waste disposal

*Control of time in relation to temperature during the complete processing cycle.

*Application of training procedures

* Control the cooking process to eliminate/reduce pathogens to acceptable levels.

Applicable legislation and Guidelines

Ghana Food and Drugs Act of 1992. PNDCL 305B

Codex Alimentarius (2009) - Basic Food Hygiene Text 4th Edition

Ghana Standards Authority - GSS:955 (2013)

CCP Decision Tree using Codex Decision tree

S.No	Process Hazard Step	Q1. Do control measures exist?	Q1a. Is control necessary at this step for safety?	Q2. Is the step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?	3. Could contamination with identified hazard(s) occur in excess of acceptable level(s) or increase to unacceptable level(s)?	4. Will a subsequent step eliminate the identified hazard(s) or reduce their likely occurrence to an acceptable level?	CCP
1	**Receiving**	**Yes**		**No**	**Yes**	**Yes**	
2	Storage of ambient Ingredients	No	No				
3	Storage chilled Ingredients	Yes		Yes			CCP1A
4	Storage Frozen Ingredients	Yes		Yes			CCP1B
5	Defrosting Poultry or meat products	Yes		No	Yes	Yes	
6	Preparation	Yes		No	Yes	Yes	
7	Cooking	Yes		Yes			CCP2
8	Service	Yes		Yes			CCP3
9	Dishing	Yes		No	No		

HACCP Plan

Step No	Process Step	CCP no	Hazard	Critical Limits	Monitoring Procedure	Frequency	Corrective Action	Verification	Responsibility	Records
2	Frozen Storage	CCP1 A	Growth of microbiological contaminants	-15 ^{O}C	Daily monitoring	3 x daily	Report to matron and remove items to alternative freezer. Call maintenance	Domestic bursar/ weekly checks	Assistant Matron in charge /	1. Refrigeration & Cold room Temperatures 2. Equipment Maintenance Record 3. Staff Trainings 4. Daily Monitoring Record
2	Chilled storage	CCP1 B	Growth of microbiological contaminants	5- 8 ^{O}C	Daily monitoring	3 x daily	Report breakdown to matron and remove items to alternative containment. Call maintenance	Domestic Bursars /Matrons Weekly checks	Assistant Matron in charge	1. Refrigeration & Cold room Temperatures 2. Equipment Maintenance Record 3. Staff Trainings 4. Daily Monitoring Record
7	Cooking	CCP2	Survival of microbiological contaminants	80 ^{O}C / 72 ^{O}C for 2 min	Every meal	As per schedule	Continue cook ing to desired temperature	Domestic Bursars/ Matrons weekly checks	Assistant matrons/Team leader	1.Food temperature record 2.Daily monitoring record
8	Service	CCP3	Growth and multiplication of microbiological contaminants and spores	Hot holding temperature ($\geq$63 ^{O}C)	Every meal	As per Schedule	Reheat to desired temperature. If out of Hot holding zone for more than 2 hours discard	Domestic Bursars/ Matrons weekly checks	Assistant matrons/Team leader	1.Food temperature record 2.Daily monitoring record

Related documents

GHP for SHSs in Ghana

FAO/WHO (2009) Basic Food Hygiene Text. 4th Edition.

Codex Decision tree and Raw material decision tree

8. SCHOOL HACCP RELATED RECORDS

I. Kitchen staff records

II. Training records

III. Equipment cleaning schedule

IV. Kitchen cleaning schedule

V. Temperature daily check

VI. Weekly audit (in house)

VII. Personnel sick and return to work form

VIII. Cooked food temperature and time monitor

IX. Probe calibration form

9. **FSA VIDEO LINK-www.food.gov.uk/business-industry/sfbb**

Safer food, better business DVD. Version 3. FSA/0662/0712. Food standards Agency. Food.gov.uk